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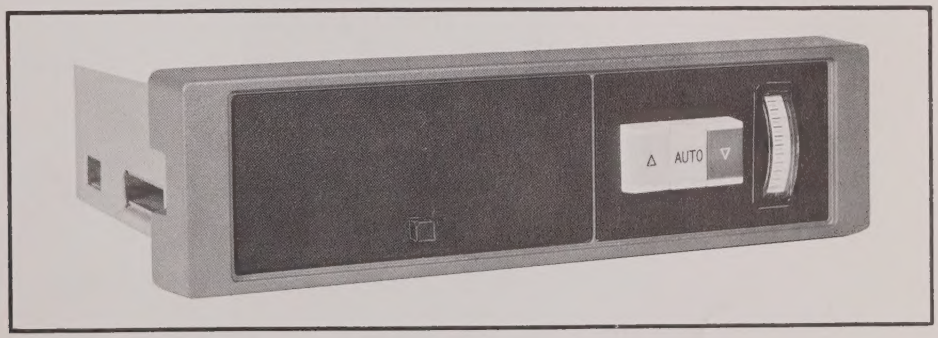
DIRECTIONS • 177529 ISSUE 2

SERIES 80 • 3-ACTION
P.A.T. CONTROLLER



CONTENTS

Section		Page
Introduction		iii
Specifications		iv
PART I DESCRIPTION OF EQUIPMENT		
1. General		1
2. Applications		1
3. Panel Controls and Indicators		3
	A. AUTO and MANUAL Pushbuttons	4
	B. Position Meter	4
	C. PROPortional BAND/GAIN Dial	4
	D. RESET Dial	5
	E. RATE TIME Dial	6
	F. APPROACH Dial	6
	G. Other Controls	7
4. Control Features in Recorders		9
	A. Control Slidewire	9
	B. Switches	9
	C. Program Control	10
	D. DC Logic Level Output	10
	E. Multiple-Point Control	10
5. Control Features Available at Terminal Board		11
	A. Low-End Maintaining Resistor	11
	B. Ungrounded Signal Common	11
	C. Inverse Rate	11
	D. High Control Senstivity	12
PART II INSTALLATION		
6. Unpacking		13
7. Mounting		13
8. Temperature Limits		13
9. Other Equipment		13
10. Wiring Connections		15
PART III PRELIMINARY CHECKS AND CALIBRATION		
11. Recorder		25
	A. Safety and Maintaining Switches	25
	B. Control Slidewire	25
12. Controller		26
	A. Manual Operation	26
	B. Proportional Action	26
	C. Reset Action and Set Point Check	26
	D. Meter Calibration	27

CONTENTS

Section Page

PART IV OPERATION

13. Manual Operation 29
14. Initial Startup 29
15. Manual to Automatic Control Transfer 29
16. Adjustment of Controller to a Process 30
    A. PROPortional BAND 30
    B. RATE TIME 31
    C. RESET 31
    D. APPROACH 34
    E. Summary of Tuning Instructions 34

PART V TECHNICAL INFORMATION

17. Controller Circuit Principles 35
    A. Basic Operation 35
    B. Proportional Action 36
    C. Reset Action 37
    D. Rate Action 37
    E. Approach Action 37
18. Controller Circuitry 38
    A. Input Circuit 38
    B. Feedback and Reset Circuit 40
    C. Chopper (Modulator) 40
    D. Oscillator (Modulator and Demodulator Driver). . 40
    E. AC Amplifier 41
    F. Demodulator 41
    G. Trigger Circuits 41
    H. Triac Oscillator Circuit 42
    I. Triac Circuit 42
    J. Logic Output (Optional) 44
    K. Power Supplies 44
    L. Manual Operation 44

PART VI SERVICING AND TROUBLESHOOTING

19. General Information 45
20. Test Equipment 45
21. Troubleshooting 46
    A. Procedure 46
    B. Checking Chassis Mounted Components 49
22. Removing Printed-Circuit Assembly from Chassis Assembly 50
23. Servicing the Printed-Circuit Card 51
24. Replacing Chassis Mounted Components and Lamps . 51
25. Resetting Factory Adjustments 51
    A. Approach Calibration 51
    B. Chopper Tuning Adjustment 52
    C. Control Slidewire Adjustment 53

INTRODUCTION

A Series 80 Position-Adjusting Type (P. A. T.) control system comprises, in general, an arrangement of the following major components, as indicated in the sketch below.

(1) A primary element sensitive to the variable quantity to be controlled, e.g., thermocouple, Rayotube® detector, emf source, etc.

(2) A recorder or indicator that measures the output of the primary element, e.g., Speedomax® G, H, W, or W/L recorder. This instrument, which also contains a control setting device, signals the controller whenever the controlled variable departs from the control set point.

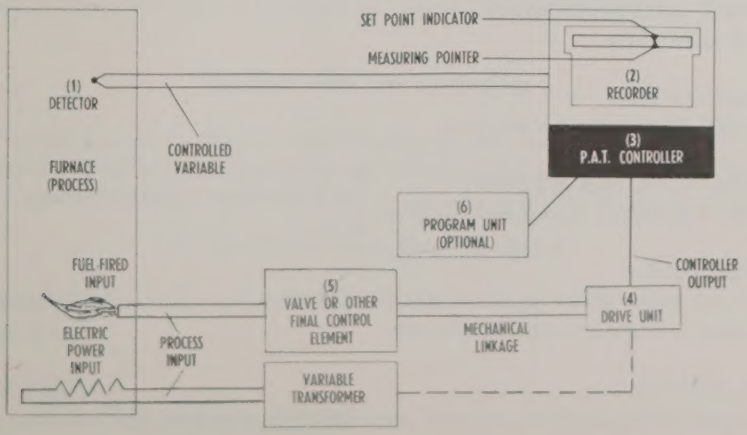
(3) **The P. A. T. controller.** This unit automatically produces a drive unit position responding to the input requirements of the controlled process. Proportional, reset, rate, and approach actions are provided to adjust for the proper response of the control valve or other final control device.

(4) An electric drive unit, with two-phase 120-volt motor and a 1000-ohm feedback slidewire. This mechanism turns in either direction from controller signals, and is mechanically coupled to the final control element.

(5) Equipment for translating the drive unit position into the process input. This equipment is usually a control valve or other final control element.

(6) Optionally, a program controller such as provided by the cam type, motor driven set point type, or electronic curve follower type.

These directions apply primarily to the controller. Information on other components of the system is included only where it pertains to their relationship with the controller. For more complete information on these other items, the user is referred to other booklets furnished with the equipment.



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SPECIFICATIONS

For Cat. 10674 Controller

INPUT SIGNAL
±4.5 volts dc from control slidewire in recorder. (Reduced to ±2 volts dc by removing terminal board jumper 7-8.)

OUTPUT
Two solid state switches. Maximum load current 5 amperes rms, 120 volts. Minimum load current 175 mA rms inductive, decreasing linearly with power factor to 125 mA rms resistive. Suitable for operating 10260 Series and 10218 Drive Units and 12411-H Reversing Contactor (L&N Part No. 031498).

AUTO PUSHBUTTON
When depressed, puts controller on automatic and is illuminated. Yellow button (for low temperature) is illuminated when valve opens on Auto; red button (for high temperature) is illuminated when valve closes on Auto. Bumpless transfer from Auto to Manual operation.

MANUAL PUSHBUTTONS
Two, momentary contact type: yellow (Δ) on left for opening valve; red (∇) on right for closing valve. No buttons illuminated for manual operation. Depressing either button releases Auto button and turns off Auto light. Bumpless transfer from Manual to Auto operation.

PROPORTIONAL BAND ADJUSTMENT
300 to 1% of recorder scale for full drive unit travel with 20% control slidewire. (Proportional Gain calibration 0.33 to 100.)

RESET ADJUSTMENT
0.02 to 100 repeats per minute in 18 steps.

RATE TIME ADJUSTMENT
0 to 8 minutes.

APPROACH DIAL
0 to 100 (arbitrary scale).

APPROACH CALIBRATION
CHOPPER TUNING CAPACITORS } Factory adjustments.

PANEL METER
Vertical edgewise type with 0-100 scale. Indicates position of drive unit and corresponding valve.

SIGNAL LIGHTS
See Auto Pushbutton above and Safety Action below.

SPECIFICATIONS

TERMINAL BOARDS
On rear of case. Knockouts take 1" conduit.

POWER SUPPLY
107 to 127 V, 50/60 Hz.

POWER CONSUMPTION
Volt-amperes: 23 VA plus 36 or 108 VA, depending upon drive unit used.

SAFETY ACTION
Recorder safety switch disconnects output and runs drive unit closed. (Either red or yellow pushbutton may be illuminated with safety switch operating.)

AMBIENT TEMPERATURE LIMITS
32°F to 140°F (0°C to 60°C).

CASE
Metal, for flush mounting on panel, or for bench use. May be stacked for mounting one or more controllers under single recorder.

DIMENSIONS
3" H x 11" W x 11-1/2" D (behind panel).

WEIGHT
About 11 lb.

For Cat. 10674-L Controller (dc logic level output)

Same as for 10674 above but in addition: Designed to operate Mark II power switch. Both outputs normally give 0-0.5 V dc level above circuit common, holding power switch off. Operation on automatic (Auto) or by pushbuttons (on Manual) turns on power switch channel with 10-24 V signal. Case has additional 10-point terminal board to which logic output is wired.

For Cat. 10674-M Controller

Same as for 10674 above but in addition: Case has additional 10-point terminal board to which commutating relay circuit card is wired.

For Amplifier When Used By Itself

INPUT IMPEDANCE
3.3 megohms.

OPEN LOOP GAIN
At maximum amplifier gain, ±0.5 mV input signal to chopper will cause triacs to run drive unit.

SERIES 80

3-ACTION P.A.T. CONTROLLER

PART I DESCRIPTION OF EQUIPMENT

1. GENERAL

The Series 80 3-Action P.A.T.—Position-Adjusting Type—controller is a solid state device that is capable of positioning a two-phase motor-operated drive unit in response to the input requirements of the controlled process. (See Introduction.) It comprises a chassis arranged to plug into an outer case. The case may be supplied attached to a Speedomax H, W, or W/L recorder for panel or bench mounting, Fig. 1. Or it may be furnished as a self-contained unit for mounting separately from the recorder, as for example with Speedomax G instruments. Two or more such controllers can be supplied for vertical mounting below a Speedomax H, W, or W/L recorder. When supplied mounted beneath the recorder case, the assembly is furnished complete with all necessary wiring between cases.

Table I summarizes the numbering system for the P.A.T. controller.

TABLE I–P.A.T. NUMBERING SYSTEM

NUMBER	DESCRIPTION
Part No. 173050	P.A.T. chassis without exterior case
Cat. No. 10674	173050 chassis with exterior case
Cat. No. 10674-L	173050 chassis with exterior case which contains additional terminals for use with dc logic level output
Cat. No. 10674-M	173050 chassis with exterior case which contains additional terminals for use with Speedomax multipoint recorders

2. APPLICATIONS

The 3-action P.A.T. controller (see also Introduction) is normally used for automatic control of processes in which the drive unit actuates dampers, vanes, valves, etc., to permit regulation of the controlled variable, usually temperature. However, when employed with an adjustable type transformer or other means of electric or electronic adjustment, it can also be used for control of electric furnaces.

The 3-action P.A.T. controller can be used in any application which requires proportional control with automatic reset and rate actions. This usually means on any process with inherent system lags in which

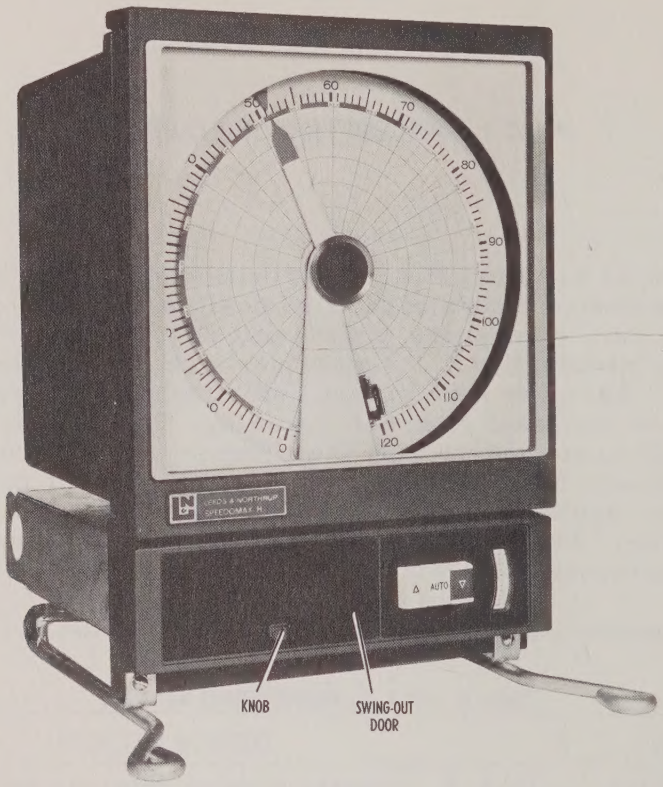

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Fig. 1–P.A.T. controller mounted below instrument case. Instrument shown is Speedomax H recorder (round chart). Illustrated for bench mounting.

control of the variable, e.g., temperature, must be maintained within close limits. It is also suitable for program control applications, such as provided by the cam type, motor-driven set point type, or electronic curve follower type. When used in program control or multiple-point recorder applications, however, the recorder with which the P. A. T. controller operates must be equipped with a 100% control slidewire. Recorders for standard control applications are normally equipped with a 20%, 116-ohm slidewire, except those for pH control which are usually equipped with a 40%, 116-ohm slidewire. See Section 4A.

The 3-action P. A. T. controller adjusts the position of the output drive unit in response to variations in temperature from the set point. With temperature stationary at the set point, the drive unit is stationary and process input is constant. If temperature drops below set point, the controller acts to increase process input by driving the valve toward the open limit, and conversely. The three actions of proportional, reset, and rate cause the position of the drive unit to change according to the magnitude, duration, and speed of departure from set point. Sections 3C, D, and E explain these functions in greater detail.

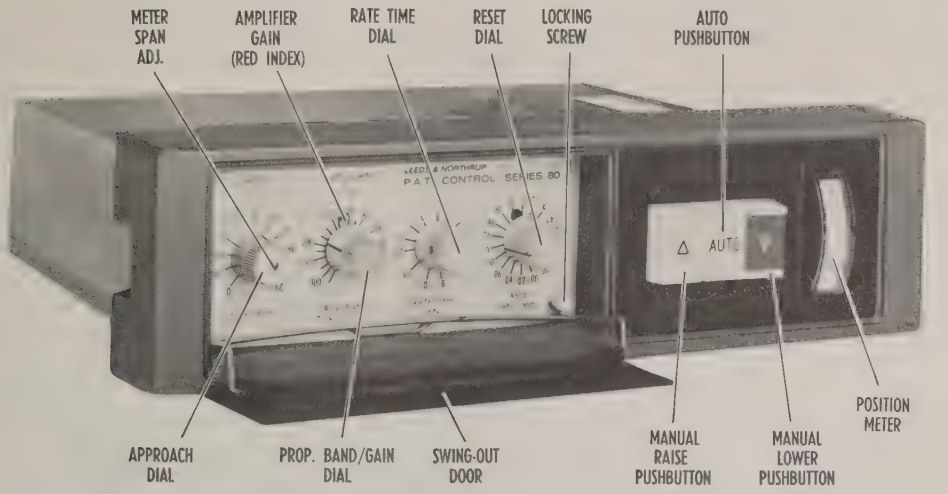

Fig. 2–P.A.T. controller (L&N Part No. 173050) without exterior case, showing panel controls and indicators.

3. PANEL CONTROLS AND INDICATORS

All pushbuttons, dials, and indicating devices used in adjusting and operating the controller are contained on the chassis front panel. Those components used when the equipment is in service are at the right side of the panel while those used for initial tuning of the controller (and only infrequently thereafter), as well as the chassis locking screw, are concealed behind the door at the left. See Fig. 2. The door is to prevent the settings from being disturbed during normal operation. It is easily swung down out of the way, or can be removed entirely if desired. Other adjustments are also located on the front panel, as well as on the printed-circuit card. These devices are described in Section 3G.

To open the door, pull the knob (near the lower edge) out and down. The door will tilt horizontally out of the way. It can be removed entirely if desired by springing the wires out of the two hinge holes.

To remove the chassis from the case, turn the chassis locking screw counterclockwise two or three turns. This should rotate the locking pawl 90° out of its slot in the bottom of the case, and allow the chassis to be pulled out of the case using the finger recesses on each side of the cast bezel. (DO NOT TURN THE LOCKING SCREW MORE THAN A FEW TURNS IN EITHER DIRECTION.)

To replace the chassis, first check the position of the locking pawl at the bottom front of the chassis. The pawl should be toward the rear of its threaded shaft, and swung up parallel to the bottom plate of the chassis. Insert the chassis into the case, allowing the connector guard to guide the chassis connector into the mating terminal board connector. After pushing the chassis carefully all the way into the case, turn the chassis locking

screw clockwise two or three turns, or until the chassis is no longer free to move in and out of the case. The chassis lock has no positive limit of adjustment—it is just meant to maintain proper insertion of the chassis connector. The locking pawl can be damaged by turning the screw too far.

3A. AUTO and MANUAL Pushbuttons

There are three pushbuttons on the right side of the controller. The center (white) one, marked AUTO, is for automatic control. The left (yellow) one, marked Δ, is for manually opening the valve, i.e., increasing the input to the process; and the right (red) one, marked ∇, is for manually closing the valve, i.e., decreasing the input to the process.

When the AUTO button is depressed, the controller functions as an automatic controller and the pushbutton is illuminated. While the AUTO pushbutton is depressed, either manual pushbutton is illuminated to indicate the direction of valve travel. On opening of the valve (and at an open limit), the yellow pushbutton (denoting low temperature) is illuminated. On closure of the valve (and at a closed limit), the red pushbutton (denoting high temperature) is illuminated. When hunting occurs, both lights flash alternately, indicating that the setting of the amplifier gain must be decreased. No buttons are illuminated when on manual control.

Note that the operation of the signal lights as discussed above is characteristic of processes which require the valve to open when the controlled variable decreases. On those processes requiring the opposite valve response, the functions of the red and amber lights are reversed. (This may be corrected by reversing the positions of the direction markers on the buttons if desired. See Fig. 7A Note 1b.)

Transfer from automatic to manual or from manual to automatic can be made at any time, regardless of whether the controlled variable is at set point or away from it.

3B. Position Meter

With the pushbuttons set for either automatic or manual operation, this meter indicates the drive unit and valve positions. Thus the pointer position (in percent of full scale) gives an approximate indication of process input (in percent of maximum input).

For reverse acting control, the polarity of the meter connections can be reversed if desired. See Fig. 7A Note 1b.

3C. PROPortional BAND/GAIN Dial

Proportional action is the corrective action in which the change of process input is proportional to deviation of the controlled variable, or recorder* pen motion, from set point. The ratio of pen motion to change

* Although the controller may be used in conjunction with an indicator, a recorder is more often employed. Therefore, for convenience, the term "recorder" is used in this and subsequent sections, and shall be understood to mean "recorder or indicator".

of process input is expressed as the proportional band and is adjusted by means of the PROP. BAND dial. A dial setting of 10%, for example, means that the recorder pen must move over a band 10% of the recorder scale width to vary process input from minimum to maximum. Fig. 3 illustrates this relationship, where a band width 40% of span is used to operate a valve or other regulating device from full on to full off at a proportional band of 40%. It should be noted that the narrower the band, the more sensitive will be the control response.

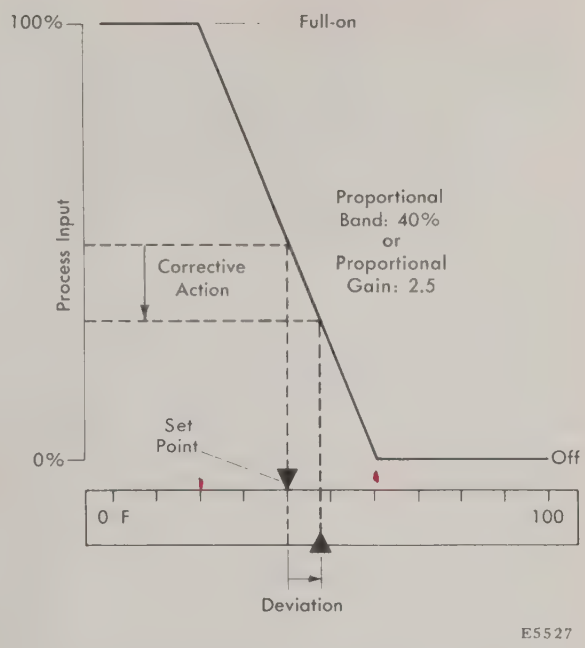

Fig. 3–Variation of process input with deviation of controlled variable for 20% control slidewire.

The proportional band dial is calibrated from 300 to 1% of recorder scale. This calibration specifically applies to a 20% control slidewire, and may also apply to a 100% control slidewire if rate action is disconnected. For a 40% control slidewire, the actual proportional band is twice the dial reading. For a 100% control slidewire with rate action, the proportional band is five times dial reading. (See Fig. 7 and accompanying notes, Section 10; also Section 5D for instructions on changing proportional band calibration, and Section 17B.)

The proportional band dial can be changed to a PROPortional GAIN dial by adding the dial label which is shipped with each controller (L&N Part No. 287458). Proportional gain is the closed-loop gain of the controller, and is the ratio of change in process variable to pen motion. For example, a dial setting of 10 means that for a recorder pen motion of 10% the process input will change ten times as much, or 100% of full-scale input. (Proportional Gain = 100/Proportional Band.) The proportional gain dial is calibrated from 0.33 to 100 for a 20% control slidewire (or a 100% control slidewire with rate disconnected). For a 40% control slidewire, divide the dial readings by 2. For a 100% control slidewire with rate action, divide the dial readings by 5.

3D. RESET Dial

Automatic Reset is an integrating action which corrects the process input at a speed proportional to the deviation of the recording pen from the set point setting. The ratio of speed to deviation is adjustable by means of the RESET dial. This control action produces a gradual change in process input as long as the recorder pen is off set point. At set point it stops.

Proportional action alone will not maintain the recorder pen at the set point when process demand changes are encountered. The proportional control provides the rapid and stable response to process demand changes which are required for close control. When reset action is superimposed upon proportional control, it provides the recognition of set point which simple proportional control lacks.

Reset speed is calibrated in "repeats per minute", which term may be explained as follows:

Suppose that the recorder pen moves away from set point so that the proportional action changes process input by 10% of maximum input, and the recorder pen remains in this position. The reset action will now produce a further change of process input at a speed which is proportional to the distance the recorder pen moved off set point. If the RESET dial is at 1.0, then in one minute reset action will add another 10% to the process input. That is, the reset action will "repeat" the proportional action once per minute. See also Section 17C.

3E. RATE TIME Dial

Rate action applies a correction to the process input which is proportional to the rate of change of recorder pen position. This corrective action, when used in conjunction with proportional and reset action, aids in overcoming the effects of process capacity and measuring lags which give the process a tendency to overshoot or cycle about the control point. The amount of rate time action depends upon the RATE TIME dial setting.

The RATE TIME dial is calibrated in minutes. The significance of the dial setting is as follows:

Suppose that the recorder pen is moving downscale from the set point at a constant rate. Then, because of proportional action, process input will change—also at a constant rate. Thus, for a given set of conditions, process input might be increasing at the rate of, say, 3% of maximum input per minute due to proportional action only. Now, if the RATE TIME dial were set at 2 minutes, process input would increase by an additional amount equivalent to 2 minutes of proportional action, i.e., 6% of maximum in the example cited. See also Section 17D.

3F. APPROACH Dial

Approach action is used under conditions of start-up or prolonged process upset, when saturation of the reset circuit can occur. When process input remains at its maximum for an extended period, proportional and reset actions will not take effect until the recorder pen has moved upscale all the way to the set point. Overshoot, of course, is then inevitable. The approach control function adds an adjustable bias voltage in the feedback circuit, causing corrective action to be taken before the recorder reaches the set point. See Fig. 4, also Section 17E.

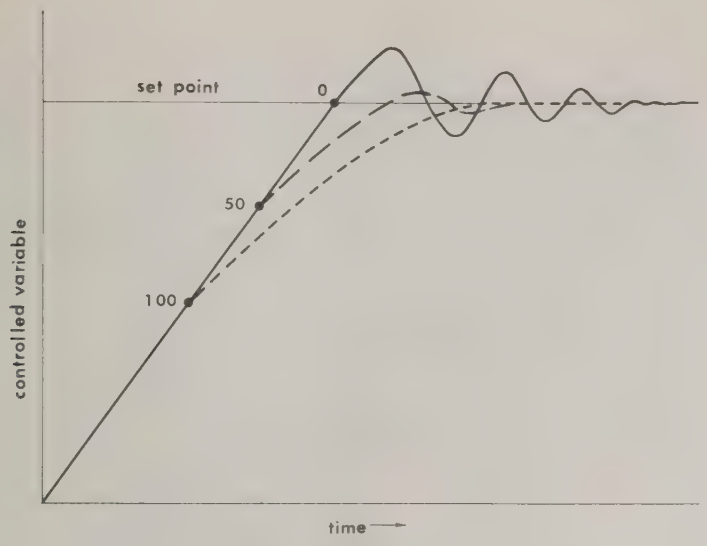

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Fig. 4–Effects of approach control setting.

The approach dial is calibrated 0 to 100, an arbitrary scale. At zero setting there is no bias voltage in the feedback, and corrective action will start at the set point after reset saturation. At 100 setting, corrective action will start when the recorder pen reaches a certain point on the control slidewire. This point is 10% below set point for a 20% control slidewire or 20% below for a 40% slidewire (the low end of the control slidewire in each case); or 10% below set point for a 100% slidewire with the rate circuit disconnected. (NOTE: If the rate circuit is connected with a 100% control slidewire, corrective action could start 50% below set point with the approach dial set at 100.)

The approach circuit is factory calibrated to operate at the open end of drive unit slidewire contact travel. If the open end limit switch cam on the drive unit is readjusted, it may be necessary to adjust the approach calibrating potentiometer. See Section 25A for instructions.

3G. Other Controls

In addition to the proportional, reset, rate, and approach adjustments located behind the swing-out door at the left side of the controller, there are two other controls located here, Fig. 2, and three adjustments located on the printed-circuit card, Fig. 5. The two controls behind the swing-out door are potentiometers for adjusting: (1) the meter span, and (2) the amplifier gain. The factory adjustments on the printed-circuit assembly are: two for chopper tuning and one for approach calibration. All are screwdriver adjustments except the amplifier gain. This is a red index adjustment that can be moved by pushing with one finger. The proportional dial calibration can be used as a reference for its position.

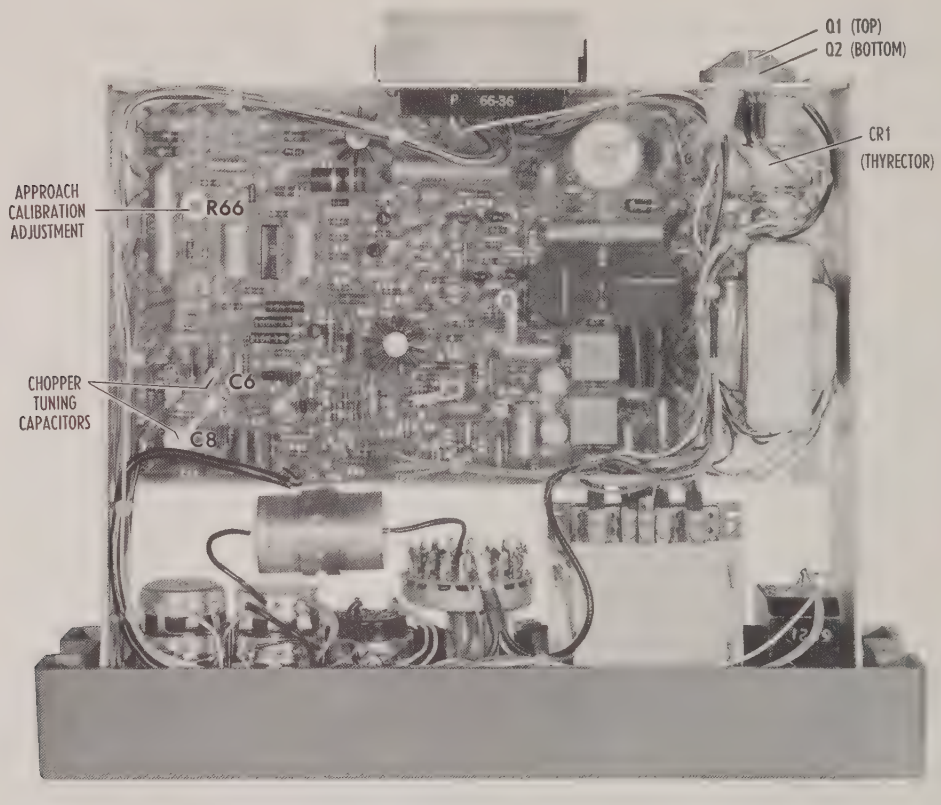


Fig. 5–Top view of controller and 444472 printed-circuit assembly showing factory adjustments, output triacs (Q1 and Q2), and Thyrector CR1.

(1) Meter Span Adjust

The meter span adjustment is located in the center of the APPROACH dial and its adjustment makes the meter read 100% at the open end of drive unit travel, as explained in Section 12D.

(2) Amplifier Gain Adjust

The gain adjustment is located behind the PROP. BAND dial and its adjustment sets the level of sensitivity or dead band in the controller. It should always be set for optimum sensitivity, as explained in Section 16A. Its setting should be checked whenever a change is made in the proportional adjustment.

The controls listed below are factory adjusted. Normally, these should not require readjustment. However, in the event the controls are disturbed, they can be reset to factory specifications by following the applicable procedure where indicated.

(3) Chopper Tuning Capacitors

Two capacitors, C6 and C8, on the printed-circuit assembly, Fig. 5, are tuned to eliminate the commutating transient spikes in the ac amplifier input. Readjustment is described in Section 25B.

(4) Approach Calibration

Also shown in Fig. 5, it provides a means of setting the feedback voltage at 0.4 volt for full-open drive unit limit. This potentiometer is factory adjusted and may need readjusting only if the drive unit limit switch cams or anti-backfire contact position is adjusted. See Section 25A.

4. CONTROL FEATURES IN RECORDERS

4A. Control Slidewire

The control slidewire, mounted on the recorder shaft, rotates to a position relative to the recorder pen position. The control slidewire may not cover the full travel of the recorder, as the measuring slidewire does. The standard control slidewire covers only 20% of the recorder scale. (The 20% length is a mechanical compromise between the adjustability of the set point indicator and the region of changing controller signal.) A longer slidewire for pH control covers 40% of the recorder scale. For each of these, the slidewire contact is mechanically adjusted as the set point indicator is moved, since the controller input bridge circuit always locates the electrical set point approximately at the center of the control slidewire.

When a separate set point slidewire is used as part of the input bridge, such as in program or multiple-point control, a control slidewire covering 100% of the recorder scale is used. In this case the set point is not at the center of the control slidewire, but at whatever point matches the set point slidewire setting.

4B. Switches

(1) Safety Switch

A cam-operated safety switch, normally provided with a 20% control slidewire, is located in the recorder. It is arranged so that when the controlled variable exceeds the set point by a preset amount, the process input is turned off (on automatic operation only). At the same time, the red pushbutton light on the controller goes on. The safety action completely bypasses the controller and, therefore, protects against any type of controller failure (but note that for some types of failure, such as a burned out lamp, the red signal light may not go on). If safety switch action is not required, however, the safety switch can be bypassed. See Figs. 7A and 7B and accompanying notes.

NOTE: After controller output has been turned off by the safety switch, if it is necessary to switch to manual control, always push the red button. Under this alarm condition, the manual output immediately after switching will be at maximum. Holding the red button in will quickly reduce the output to the desired value.

(2) Maintaining Switch

A cam-operated maintaining switch, located in the recorder, is normally provided with a 40% control slidewire. It is adjusted so that when the control slidewire rotates to bring the contact to the high end, the switch closes and maintains electrical connection between contact and high end even when the contact goes beyond the end of the slidewire.

4C. Program Control

Program control usually makes use of: (1) A set point slidewire or slidewire contact that is mechanically coupled to a motor-driven cam or electronic curve follower (e.g., L&N Trendtrak™ curve follower); or (2) A slidewire that is mechanically coupled to a recorder set point indicator and motor driven to provide various rates of heating, cooling, soaking, etc. (sometimes referred to as a motor-operated front setter type of control). The 100% control slidewire is provided as an integral part of the recorder. Speedomax G, H, and W recorders can be so equipped. Relays, timers, and interrupters that work in conjunction with the program cycle are usually supplied for separate mounting nearby.

In this application the program (set point) slidewire position is moved through its cycle, as determined by the shape of the cam, the curve on the Trendtrak curve follower, or the timing of the motor-driven front setter switches. The program and 100% control slidewires form a bridge circuit. The output or unbalance of this bridge is fed into the controller which acts to increase or decrease its output in accordance with deviation of the control slidewire from the driven program slidewire. See Fig. 7C and accompanying notes. Usually a limit switch opens at the end of the program to shut the system down.

4D. DC Logic Level Output

When the L&N Mark II Power Switch is used to operate the drive unit, the power switch may be operated directly from the trigger circuit of the controller, bypassing the output triacs. A special case with extra 10-point terminal board makes the logic level output available for this application, on Auto or manual. See Figs. 7E and 7F and accompanying notes.

4E. Multiple-Point Control

In this arrangement control can be provided on one or more points to either a common set point or individual set points. A standard controller, plugged into a special case assembly, is required for each point to be

controlled. The recorder control slidewire, in combination with each of the set point slidewires, forms individual bridges, each producing an error signal representing deviation of the controlled variable from set point. At the time of measurement by the recorder a commutator relay (shown between terminals 21 and 22, Fig. 7D) in the corresponding controller case is energized. Its contacts close momentarily to apply the error voltage to the memory capacitor, which is the capacitor normally connected as the rate capacitor for single-point control. This action may cause the controller to either increase or decrease its output in response to the change in charge. Thus, as the recorder recycles, the error voltage from the control bridge updates the charge on the memory capacitor to provide continuous regulation of process inputs from corresponding controllers. Rate action is not available on multiple-point control. Although the rate dial is still part of the controller chassis, it is not connected in the circuit. See Fig. 7D and accompanying notes.

5. CONTROL FEATURES AVAILABLE AT TERMINAL BOARD

5A. Low-End Maintaining Resistor

A 470-ohm resistor is normally supplied on the terminal board of controllers used with 20% and 40% control slidewires. See Figs. 7A, 7B, and 14. It is usually connected between terminals 9-13. The resistor acts to maintain electrical contact between the control slidewire contact and the low end of the slidewire whenever the contact goes beyond the end of the slidewire. It has a shunting effect on the slidewire resistance between contact and low end. This shunting effect moves the electrical center of the control slidewire bridge about 2-1/2% of the recorder scale above the mechanical center of the control slidewire. This offset is cancelled by proper adjustment of the control slidewire on the recorder shaft. See Section 25C.

5B. Ungrounded Signal Common

Some applications require an ungrounded or floating circuit. This can be accomplished by removing the terminal board jumper between terminals 14-15 at the back of the controller. (See Fig. 7.) Removing this jumper may introduce a small offset between set point and control point, however, so the circuit should be kept grounded except for special requirements. Terminal 14 must still be connected to earth ground.

5C. Inverse Rate

Inverse rate provides a stable control signal on processes which tend to fluctuate violently, such as on pH or flow control. For these conditions the rate capacitor is disconnected from the 10K ohm resistor in the input circuit and reconnected to signal common. This has the effect of reducing the noise in the signal. The rate potentiometer is now used to adjust the time constant of a low-pass filter. The normal rate graduations are now multiplied by 6 to give the time constant in seconds of the RC filter. The filter cut-off frequency may be calculated by dividing .0265 by the rate

dial reading. As noted in Fig. 7A Note 3, inverse rate is accomplished by removing the link from between terminals 11 and 12 and reconnecting it between terminals 12 and 13.

5D. High Control Sensitivity

The control sensitivity can be increased by a factor of 10 by reversing the rate action voltage divider at the input circuit. This is done by removing the jumpers between terminals 10-11 and 13-15, and adding jumpers between terminals 10-13 and 12-15. This of course will change the proportional band and proportional gain calibrations by a factor of 10. Proportional band readings should be divided by 10; proportional gain readings should be multiplied by 10. Rate action can no longer be used with this circuit but inverse rate can be used. See Fig. 7A Note 3.

PART II INSTALLATION

6. UNPACKING

After removing the instrument from its packing case, loosen the chassis fastener (locking screw) behind the door on the dial plate, Fig. 2. This is accomplished by turning the screw counterclockwise two or three turns. (See Section 3, beginning.) The chassis can now be pulled forward out of the case. Remove and discard any packing material or shipping ties from the chassis. Then make sure all push-on wire sockets are seated firmly on their respective pins before replacing the chassis in the case.

> IMPORTANT: If for any reason the controller is to be sent back to Leeds & Northrup Company, it must be properly packed to prevent damage during shipment. If the original packing material and shipping ties have been removed, replace them and return the unit in the same container in which it was shipped.

7. MOUNTING

(1) If the controller is supplied as part of a Speedomax H or W instrument, follow the mounting instructions given in the respective Speedomax H or W recorder manual.

> NOTE: If two or more controllers are mounted under a single recorder, the controller cases will be fastened together with straps behind the dress plate. These straps and the screws which hold them are discarded after the assembly is positioned in the panel cutout, and then the cases are bolted directly to the panel.

(2) If the controller is supplied as a separate unit, it should be mounted in a readily accessible location near the recorder (usually directly below the recorder on the panel). The controller is arranged for flush mounting only. All necessary mounting dimensions are given in Fig. 6.

8. TEMPERATURE LIMITS

The controller should not be installed in locations where the ambient temperature exceeds the limits 32°F and 140°F (0°C and 60°C).

9. OTHER EQUIPMENT

For instructions on installing the recorder, drive unit, control valve, or power switch, refer to the booklets furnished with such equipment.

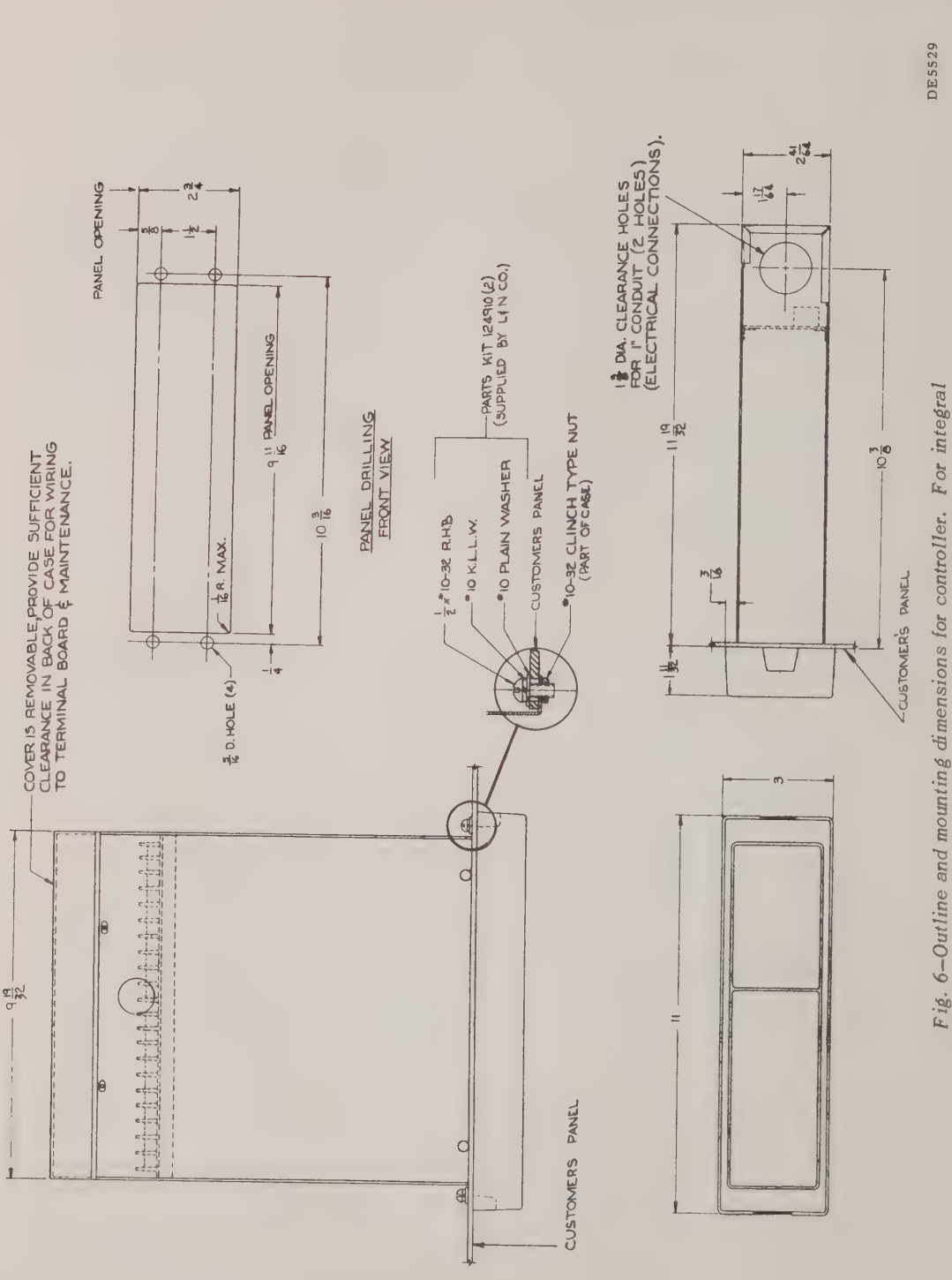


Fig. 6—Outline and mounting dimensions for controller. For integral mounting with recorder, see recorder manual.

10. WIRING CONNECTIONS

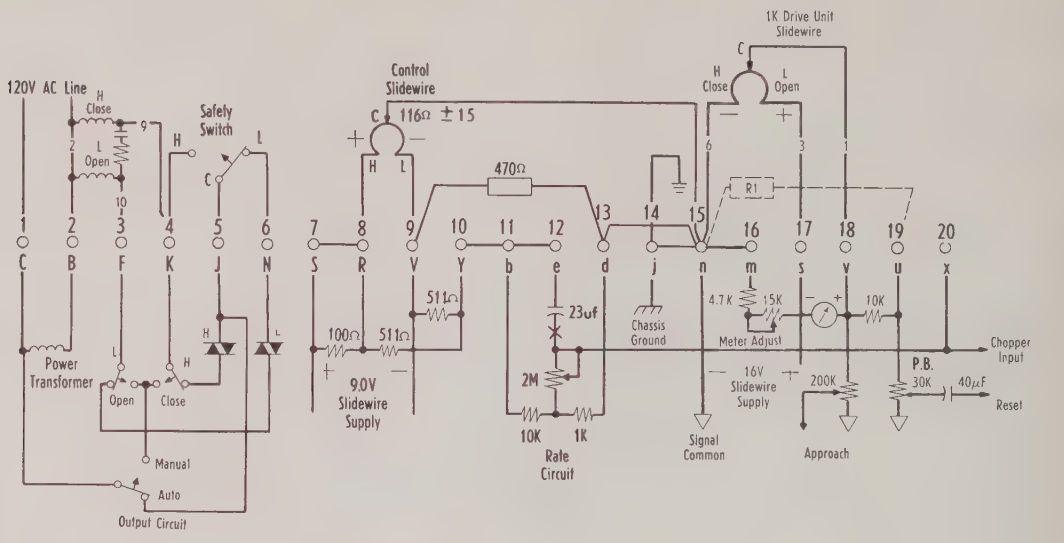
Wiring connections to the various units of the control system are to be made in accordance with the diagram furnished for the system. Special attention should be given to the notes on the diagram.

Fig. 7 shows various installation schemes for different modes of control. Note that the scheme used will depend to a large extent on how the instrument is equipped. For example, program control requires a 100% control slidewire in the recorder as well as a 100% set point or program slidewire. The schemes shown in Fig. 7 illustrate the various ways the equipment can be used. Pay particular attention to the connections to be made at the back of the controller and how these may affect recorder and controller operations. The notes apply to the particular sketch as indicated. Changes can be made as required by following the applicable procedure. In making actual connections for the type of system ordered, be sure to refer to the diagrams furnished with the equipment.

Note that the grounded side of the power line is connected to terminal 2 of the controller terminal board. Always connect terminal 14 of the controller terminal board to earth ground (green wire).

In addition, always make sure that the drive motor (connected to the output of the P.A.T.) has a resistor (consult motor manufacturer's specifications) in series with the phasing capacitor, because there is a possibility that for an infinitesimal period of time the one triac could be still conducting while the other triac is triggered "on". When this happens, the phasing capacitor is shorted, and the high short circuit current can damage the triac's.

This problem does not exist with regular L&N drive units, but only with other than L&N drive units.



E5580

Fig. 7A–20% or 40% control slidewire with safety switch.

Fig. 7A Notes: (20% or 40% Control Slidewire with Safety Switch)

1. Control Action

a. Wired as shown, when the recorder measuring pointer moves to the left of the set point indicator (terminal 10 is positive with respect to terminal 15), terminal 3 connects 120 V line to the drive unit, turning its shaft CCW, which normally opens the valve (red drive unit index travels toward 100 on the left-hand scale of Cat. 10260 Series drive units), and increases meter reading. Safety action connects 120 V line to terminal 4 and runs the drive unit CW to close the valve. (Decreasing temperature opens the valve, and excessively high temperature closes the valve.)

b. To reverse control action:

(1) Reverse the leads to terminals 9 and 10 on the drive unit.
(2) Reverse the leads to terminals 3 and 6 on the drive unit.
(3) Move the controller terminal board jumper from terminals 15-16 to terminals 16-17.
(4) Reverse the connections to the meter terminals on the controller chassis.
(5) Direction markers on the yellow and red pushbuttons may be reversed by sliding the display screens sidewise out of the pushbuttons and putting them back upside down.

(Decreasing temperature will now close the valve, and excessively high temperature will open the valve.)

c. To convert the safety switch to a high-end maintaining switch: (Colors of leads in parentheses apply if wired by L&N.)

(1) Move the (yellow) lead from terminal 4 to 8.
(2) Move the (red-yellow) lead from terminal 5 to 15.
(3) Move the (orange) lead from terminal 6 to 13.
(4) Connect 128389 jumper between terminals 5-6.
(5) Reset the recorder cam to operate the switch just before the control slidewire contact leaves the high end of the control slidewire.

Fig. 7A Notes *(Cont'd.)*

2. Proportional Dial Calibration

a. The proportional dial is calibrated for a 20% control slidewire. With a 40% control slidewire, the proportional signal is reduced to 1/2, so proportional band dial readings must be multiplied by 2, or proportional gain dial readings must be multiplied by 1/2.

b. To obtain the correct proportional dial calibration for a 40% control slidewire (if desired), connect a 6,800-ohm resistor between terminals 15-19.

3. Inverse Rate or Input Signal Filter

a. The rate action circuit may be converted to an adjustable low-pass filter, or inverse rate, by moving jumper 11-12 to 12-13. Use the rate time dial to adjust the filter time constant. (See Section 5C.)

b. Control sensitivity and proportional voltage may be increased by a factor of 10, and inverse rate may be used at the same time, by:

(1) Removing jumpers 10-11 and 13-15, and
(2) Adding wire jumpers 10-13 and 12-15.

(Using this circuit, proportional band readings must be divided by 10 or proportional gain dial readings multiplied by 10. See Section 5D.)

4. Isolating Signal Common from Ground

If necessary, signal common may be isolated from chassis ground by removing jumper 14-15. This may cause a slight offset between control point and set point. Terminal 14 must still be connected to earth ground.

5. Separately Mounted Controller

If shipped as a separate controller, Catalog No. 10674, the terminal board will include a jumper between terminals 5-6. This should be removed if a safety switch is used.

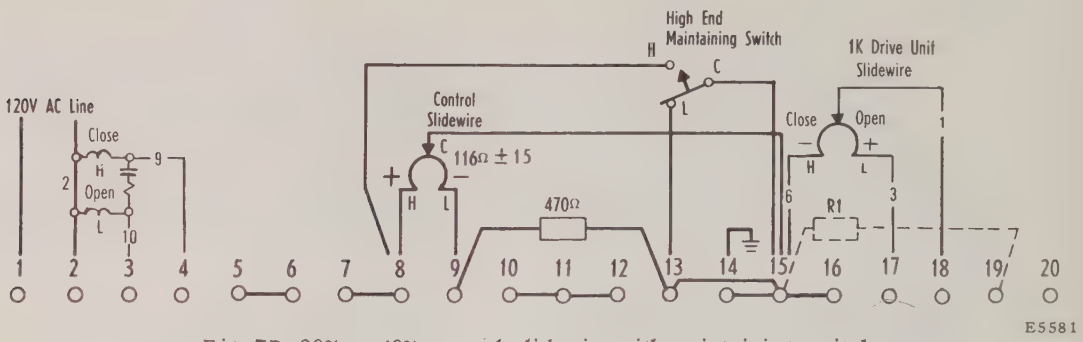


Fig. 7B–20% or 40% control slidewire with maintaining switch.

Fig. 7B Notes: (20% or 40% Control Slidewire with Maintaining Switch)

1. Control Action

   a. Same as Fig. 7A Note 1a.

   b. Same as Fig. 7A Note 1b.

   c. To convert the maintaining switch to a safety switch:
   (Colors of leads in parentheses apply if wired by L&N.)

   (1) Remove the jumper from terminals 5-6.
   (2) Move the (yellow) lead from terminal 8 to 4.
   (3) Move the (red-yellow) lead from terminal 15 to 5.
   (4) Move the (orange) lead from terminal 13 to 6.
   (5) Reset the recorder cam to operate the switch at the desired distance to the right of the set point indicator.

2. Proportional Dial Calibration, Inverse Rate, Isolating Signal Common from Ground, and Separately Mounted Controller

   See Fig. 7A Notes 2, 3, 4, and 5.

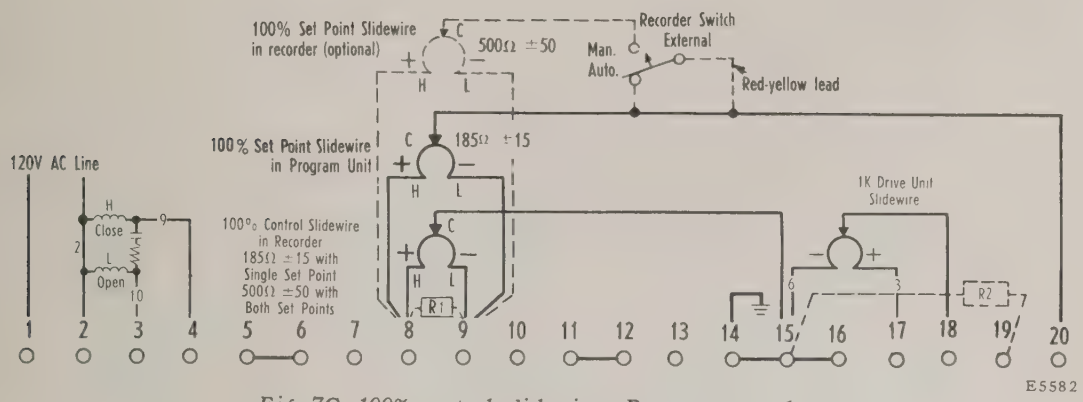


Fig. 7C–100% control slidewire. Program control.

Fig. 7C Notes: (100% Control Slidewire. Program Control)

1. Single and Dual Set Point Slidewires

   a. Both program and control slidewires are 185-ohms resistance when the set point is a single program control slidewire.

   b. Both control and manual set point slidewires are 500-ohms resistance when two set points are used (one in program unit and one in recorder, with selector switch in recorder). The program set point slidewire is still 185 ohms. In this circuit, the slidewire bridge voltage is 5 V instead of 4 V, which gives 25% more proportional action than the dial indicates. This may be corrected by connecting a 680-ohm resistor between terminals 8-9, if desired. (Not needed if rate action is connected.)

2. Control Action

   a. Wired as shown, when the recorder measuring pointer moves below the position of the set point indicator (terminal 20, or 11, is positive with respect to terminal 15), terminal 3 connects 120 V line to the drive unit, turning its shaft CCW, which normally opens the valve (red drive unit index travels toward 100 on the left-hand scale of the Catalog 10260 Series drive units).

   b. To reverse control action, see Fig. 7A Note 1b.

3. Connecting Rate Action Circuit

   a. The controller as shipped has its rate action circuit disconnected. Operating the rate time dial has no effect on the controller output.

   b. To add rate action if needed:

      (1) Move the (brown-yellow) lead from terminal 20 to 11.
      (2) Add jumpers between terminals 7-8 and 13-15. This circuit reduces the proportional action (and control sensitivity) by a factor of 5. Multiply the proportional band dial readings by 5, or multiply proportional gain dial readings by 1/5. To correct calibration, see Fig. 7C Note 4.

Fig. 7C Notes *(Cont'd.)*

4. Proportional Dial Calibration

a. The proportional dial is calibrated for a single set point slidewire, as shipped. If rate action is added, per Fig. 7C Note 3b, calibration is off by a factor of 5.

b. To obtain correct proportional dial calibrations, connect the following R1 and R2 resistors to the terminal board as indicated:

Recorder Slidewires	Rate Action	R1(Term. 8-9)	R2(Term. 15-19)
1—185 ohms	No	---	---
2—500 ohms	No	680 ohms	---
Either 1 or 2	Yes	---	1,800 ohms

5. Inverse Rate or Input Signal Filter

The adjustable low-pass filter, or inverse rate, circuit may be connected by:

(1) Moving the (brown-yellow) lead from terminal 20 to 13.
(2) Removing the jumper from terminals 11-12.
(3) Adding a jumper between terminals 12-15.

Use the rate time dial to adjust the filter time constant. (See Section 5C.)

6. Isolating Signal Common from Ground

See Fig. 7A Note 4.

7. Separately Mounted Controller

If shipped as a separate controller, Catalog No. 10674, the terminal board will include all the jumpers and a 470-ohm resistor as shown on Fig. 7B. Remove the resistor and all jumpers not shown on the installation diagram. (For no rate action, this means removing jumpers 7-8, 10-11 and 13-15.)

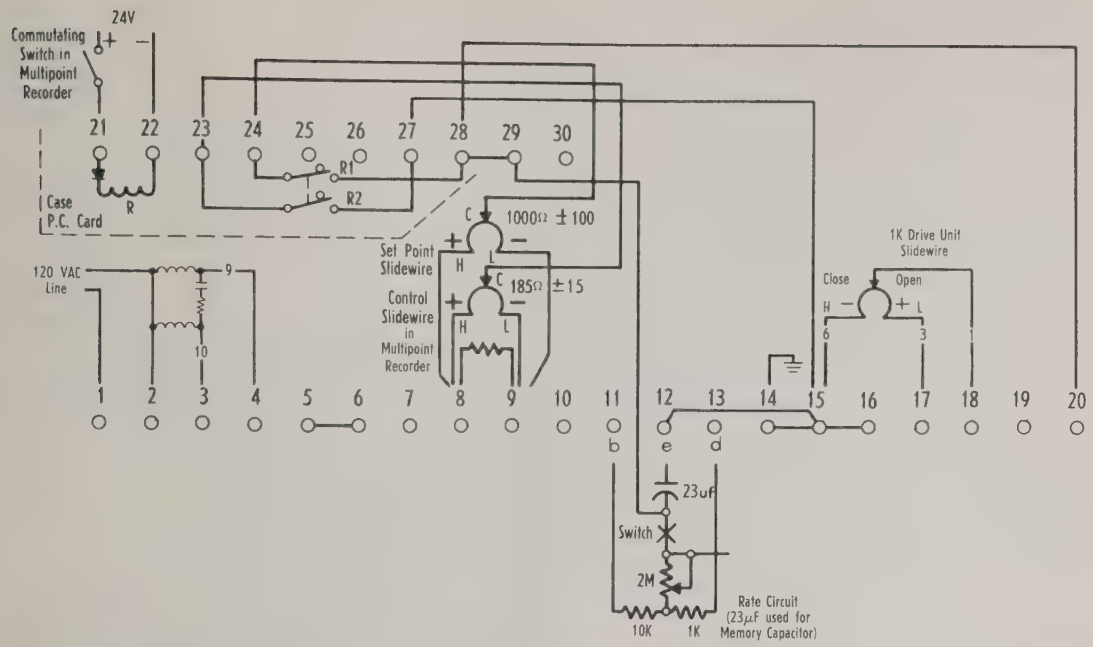


Fig. 7D–Multiple-point control. 100% control slidewire.

Fig. 7D Notes: (Multiple-point control. 100% Control Slidewire)

1. Slidewire Power Supply

   a. The 9 V regulated power supplies, dropped to 4 V through the 100-ohm resistor between terminals 7-8, are all connected in parallel across the control and set point slidewires. All controllers, except the one on Point 1 of the multipoint recorder, have a 100-ohm resistor on the terminal board between terminals 8-9. The controller on Point 1 should have 220 ohms across its 8-9 terminals, since this shunts the 185-ohm control slidewire to the same 100-ohm load.

   b. Note that P. A. T. and C. A. T. Series 80 controllers both use 4 volts to supply their multiple-point input bridges, so they may be used together on the same recorder. However, the D. A. T. Series 80 uses 9 volts on its multiple-point input bridge. If a D. A. T. controller is used on the same multiple-point recorder with P. A. T. or C. A. T. controllers, it is essential that a 100-ohm resistor be connected in series with terminal 8 of the D. A. T. controller, taking the place of the internal 100-ohm resistor between terminals 7-8 of the P. A. T. and C. A. T. controllers.

2. Control Action

   a. Wired as shown, when the recorder measuring pointer reaches a balance on Point 1 an increasing distance below the Point 1 set point on each succeeding measurement (terminal 24 is positive with respect to terminal 23 at recorder balance), terminal 3 connects 120 V line to the drive unit, turning its shaft CCW, which normally opens the valve (red drive unit index travels toward 100 on the left-hand scale of the Cat. 10260 Series drive units), and increases the meter reading. (Decreasing temperature opens the valve.)

   b. To reverse the control action of the controller on any point, see Fig. 7A Note 1b.

Fig. 7D Notes *(Cont'd.)*

3. Isolating Signal Common from Ground

The input bridge, common to all controllers, is connected to signal common at each controller in turn while its point is being measured. The signal common of any or all controllers may be isolated from chassis ground by removing jumper 14-15 from the terminal board. This may cause a slight offset between control point and set point on the isolated controllers. Terminal 14 of all controllers should remain connected to earth ground.

4. Separately Mounted Controller

If shipped as a separate controller, Catalog No. 10674-M, the terminal board will include a 100-ohm resistor between terminals 8-9. For one controller on each multiple-point recorder (usually Point 1), this resistor should be replaced with the 220-ohm resistor shipped with the controller.

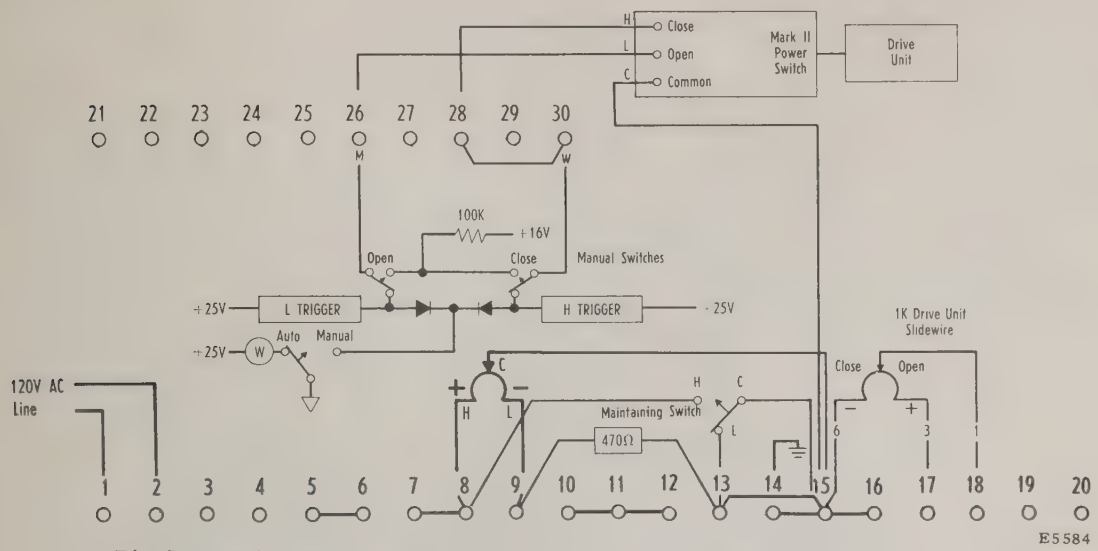


Fig. 7E–Logic output controller–20% or 40% control slidewire, maintaining switch.

Fig. 7E Notes: (Logic Output Controller–20% or 40% Control Slidewire, Maintaining Switch)

1. Control Action

   a. Wired as shown, when the recorder measuring pointer moves below the set point indicator (terminal 10 is positive with respect to terminal 15), the voltage on terminal 26 is 10-24 V and on terminal 28 it is 0-0.5 V, referred to terminal 15 as common. This signal should trigger the power switch to run the drive unit in a direction to open the valve, and the meter reading should increase. (Decreasing temperature opens the valve.)

   b. To reverse control action between the controller and power switch:

      (1) Reverse the leads from controller terminals 26 and 28 to the power switch.
      (2) Reverse the leads from controller terminals 15 and 17 to the drive unit slidewire.
      (3) Move the controller terminal board jumper from 15-16 to 16-17.
      (4) Reverse the connections to the meter terminals on the controller chassis.
      (5) Direction markers on the yellow and red pushbuttons may be reversed by sliding the display screens sidewise out of the pushbuttons and putting them back upside down (yellow ▽, red △).

2. Proportional Dial Calibration, Inverse Rate, and Isolating Signal Common from Ground

   See Fig. 7A Notes 2, 3, and 4 for further data which also apply to this circuit.

3. Separately Mounted Controller

   If shipped as a separately mounted controller, Catalog No. 10674-L, the terminal board will include all jumpers and 470-ohm resistor as shown in Fig. 7E. This controller is not designed for use with a safety switch; any 20% or 40% control slidewire application must use a maintaining contact. (See Fig. 7A Note 1c for converting a safety switch to a maintaining switch.)

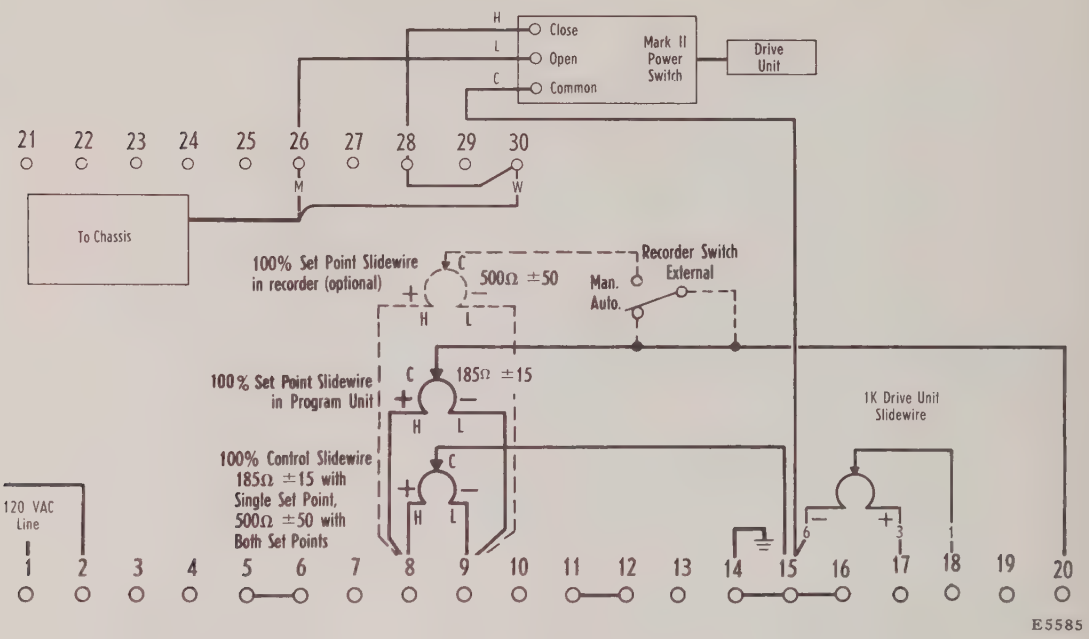


Fig. 7F–Logic output controller–100% control slidewire. No rate action.

Fig. 7F Notes: (Logic Output Controller–100% Control Slidewire. No Rate Action)

1. Control Action, Single and Dual Set Point Slidewires, Connecting Rate Action Circuit, Proportional Dial Calibration, Inverse Rate or Input Signal Filter, and Isolating Signal Common from Ground

   See Fig. 7 Notes E1, C1, C3, C4, C5, and A4, respectively, which also apply to this circuit.

2. Separately Mounted Controller

   If shipped as a separately mounted controller, see Fig. 7E Note 3. For a 100% control slidewire installation, remove the 470-ohm resistor and all jumpers not shown on the installation diagram. (For no rate action, this means removing jumpers 7-8, 10-11 and 13-15.)

PART III PRELIMINARY CHECKS AND CALIBRATION

11. RECORDER

After the installation is completed the operation of each unit of the control system should be checked before the equipment is actually put into service. General checking procedures for recorder, drive unit, power switch, etc., are to be performed according to the separate instructions furnished with such equipment. Preliminary checks and adjustments, and calibration, specific to operation of the P. A.T. system, are given in this section.

Check the recorder to be sure that it is indicating and recording the output of the primary element properly. If desired, the control can be turned off during this check by placing the CONTROL ON-OFF switch in the OFF position, if such a switch is provided. For a Speedomax H, W, or W/L instrument having no CONTROL ON-OFF switch, the control can be turned off by removing the controller chassis from its case. (See Section 3, beginning.)

11A. Safety and Maintaining Switches

Check the setting of the safety switch or the circuit maintaining switch which is located in the recorder. The factory setting of the switch is indicated on the control installation diagram. Usually the safety switch is set to operate when the measuring pointer is above the set point indicator by 2-1/2% of full scale, but it may be adjusted to operate for a departure as great as 10%. On pH, conductivity, gas analysis, and other processes which cannot stand the abrupt changes produced by safety contact action, no safety switch is used, but a circuit maintaining switch is provided. This circuit maintaining switch is set to operate when the control slidewire contact is at the high end of the control slidewire. See Figs. 7A and 7B, and Section 4B.

11B. Control Slidewire

The control slidewire, located in the recorder, normally requires no initial adjustment. However, if the factory setting has been disturbed, a rough preliminary adjustment should be made as follows:

Line up the measuring pointer and set point indicator and then pull the controller chassis out of its case. (See Section 3, beginning.) Using a suitable ohmmeter, adjust the control slidewire until the resistance measured between terminals 9 and 15 of the controller case is equal to that between terminals 15 and 8.

In all cases, a precise adjustment of the control slidewire should be made after the unit is placed on automatic control, as instructed in Section 25C.

12. CONTROLLER

12A. Manual Operation

Snap the CONTROL ON-OFF switch to ON, or plug the controller chassis back into its case if it has been removed during the preceding checks. Then depress first the left-hand pushbutton and then the right-hand one, and observe that the position meter increases and then decreases. Return the output level to the midposition on the meter scale.

12B. Proportional Action

Proceed as follows:

(1) Set the controller dials thus:

Proportional Band	50
*(Proportional Gain	2)
Reset	.02
Rate Time	OFF
Approach	0

(2) Set the recorder set point indicator and measuring pointer together.

(3) Depress the AUTO pushbutton.

(4) Move the measuring pointer downscale from set point and observe the direction in which the process input changes. If the direction is not right to the control the process (e.g., for control of a heating process the fuel valve should open on low temperature), change the wiring as indicated on the diagram to reverse the control action.

(5) Move the measuring pointer in the proper direction to operate the safety switch. Process input should now operate to the safe limit, e.g., on a heating process, excessively high temperature should shut the fuel off.

12C. Reset Action and Set Point Check

(1) Turn the recorder switch off and set the controller dials as follows:

Proportional Band	20
(Proportional Gain	5)
Reset	1
Rate Time	OFF
Approach	0

* To add the proportional gain dial sticker: (1) Loosen the setscrew holding the proportional band knob on the shaft of the potentiometer and remove the knob. (2) Set the red index to 40. (3) Peel the backing from the sticker. (4) Apply the lower half of the sticker to the dial plate. Align it first so that (a) the hole in the sticker lines up with the arc printed on the dial plate below the shaft, and (b) the calibrating lines on the sticker line up exactly with corresponding calibrating lines on the dial plate. (5) Turn the red index to its CW limit, through the slit in the sticker. (6) Apply the upper half of the sticker to the dial, still matching the calibrating lines. (7) Mount the knob on the shaft, within 1/32 inch of the dial plate, and tighten the setscrew.

(2) Depress the right-hand manual pushbutton to bring the position meter to zero.

(3) With the set point indicator at least 10% below the measuring pointer, depress the AUTO pushbutton. The meter reading should increase to maximum.

(4) Switch to manual and bring the meter to midscale.

(5) With the set point indicator and measuring pointer together, depress the AUTO pushbutton. If the output starts to increase, move the set point indicator slowly upscale until it stops. If it decreases, move the set point indicator downscale until it stops.

(6) Gradually increase the setting of the RESET dial, making small set point readjustments to hold the meter reading steady. The final adjustment should be made with the reset dial at 100. (Note that if the meter goes off scale at any time, it can be brought back on by temporarily switching to manual operation and running it back to midscale, and then transferring back to AUTO.)

(7) If the final set point indicator position is offset from the measuring pointer by more than 0.2% of recorder scale, the position of the control slidewire should be rotated on the recorder shaft. See Section 25C for making this adjustment.

12D. Meter Calibration

The meter is factory calibrated to read 100% for the wide open position of the valve. If the drive unit position is less than 100% for wide open valve (usually requiring a change in drive unit limit switch setting, which also restricts the travel of the slidewire contact), the meter span adjustment can be used to change the meter span. With the valve at its open limit, simply adjust the meter span adjusting potentiometer to make the meter read 100%. (Counterclockwise adjustment decreases meter reading.)

PART IV OPERATION

13. MANUAL OPERATION

It is advisable to operate a new control system by manual control before placing it on automatic control. In this way, if the process is not found to be stable under manual operation, e.g., due to improper valve sizing, it should not be expected to be stable under automatic operation. Thus manual operation permits the process to be observed and any cycling corrected before such cycling is blamed on incorrect controller settings.

14. INITIAL STARTUP

To place the control system on manual operation, proceed as follows:

(1) Adjust the set point indicator on the recorder to the desired value.

(2) Set the controller's dials at the following initial settings:

Proportional Band	50
(Proportional Gain	2)
Amplifier Gain (Red index on proportional dial)	CW limit
Reset	0.02
Rate Time	0
Approach	0

(3) Push the red or yellow pushbutton to release the AUTO pushbutton and place the controller on manual control.

(4) Turn on the recorder switch, and the controller switch (if any).

(5) Push the yellow button to increase, or the red button to decrease, the manual output to the desired value.

(6) Manually operate the process long enough to study the nature of the control record. If cycling occurs during manual operation, eliminate it, if possible, before transferring to automatic control.

15. MANUAL TO AUTOMATIC CONTROL TRANSFER

To transfer from manual to automatic control, push in the white AUTO button firmly, waiting at least a moment after the last change in manual output. There should be no abrupt change in the position of the final control device regardless of whether the controlled variable is at or away from the set point. The AUTO button should now be lighted, and the red and yellow buttons should flash alternately, indicating drive unit hunting. Turn the amplifier gain CCW just until the lights stop flashing.

16. ADJUSTMENT OF CONTROLLER TO A PROCESS

While theoretical methods have been devised for determining initial control settings, experience has shown an experimental approach to be the most practical and least time consuming for most installations. Such an approach merely requires observing the recorder chart or indication for signs of incorrect adjustments, as described in the following sections.

In making a series of adjustments, particularly in temperature control applications, allow sufficient time between adjustments to permit conditions to stabilize. Failure to do so may lead to wrong conclusions about individual control settings, and frequently results in loss of time in "tuning" the controller to the particular process.

For some processes where operating conditions vary widely, it may be necessary to make final adjustments which are a compromise for best overall control action. In any case, it is good practice to avoid tuning the controller to a point of sensitivity where minor changes in process conditions can introduce a cyclic system response. In general, good control settings are those which produce satisfactory results without sacrifice of control stability.

After the best settings have been determined, they should be recorded in a suitable place so the dials can be reset if the settings are disturbed in any way. A label is provided on the back of the controller door for this purpose. Either pencil or ball-point pen may be used, and either one may be erased to change the figures.

16A. PROPortional BAND

To obtain a proper initial setting for the PROPortional BAND (GAIN), set the RESET dial at 0.2, RATE TIME at 0, and switch the system to automatic control. Start with a reasonably wide band or low gain setting (about 50% proportional band or gain of 2 for temperature control applications), and turn the dial clockwise systematically until the control record becomes cyclic. Allow sufficient time after each adjustment to permit the system to stabilize. Once steady cycling becomes evident, note the approximate frequency of response and turn the dial counterclockwise until cycling is eliminated. Effects of various proportional settings for a typical temperature control system are shown in Fig. 8.

Note that the optimum setting of amplifier gain is directly related to the proportional dial setting. Proportional action is increased by turning the dial clockwise, whether the proportional band or the proportional gain calibration is used. The amplifier gain should be increased (turned clockwise) after each proportional action increase, to obtain the best control sensitivity without causing drive unit hunting. Conversely, any decrease in proportional action is likely to cause drive unit hunting. So amplifier gain will have to be reduced to stop the hunting. For best control results, the amplifier gain should always be set a little below the point where drive unit hunting occurs.

When making these and similar proportional adjustment, it will be seen that a change in setting produces an immediate and corresponding change in process input. If the reset setting (Section 16C) is sufficiently high, this change in input will be temporary and produce at most a small pip in the control record; if reset is too low, the change will tend to persist, producing an offset in the record. Where undesirable, such shifts can be avoided by switching the system to manual control before each adjustment, and then switching back to automatic control.

16B. RATE TIME

After the initial proportional setting has been determined, add minimum rate action by turning the RATE TIME dial to 0.01. To observe the effect of this setting, introduce minor upsets into the system by making small changes in the recorder set point indicator. If cycling develops, note the frequency. If the cycling frequency is somewhat higher than that resulting from too much proportional action, the process probably has a short time lag and will not take rate action. In this case, turn the RATE TIME dial back to zero and proceed with Section 16C.

If the process is one with appreciable time lag, increase the RATE TIME progressively, introducing minor upsets by set point change after each increase to disclose any tendency toward cycling. Once cycling becomes evident, decrease the setting until cycling is eliminated.

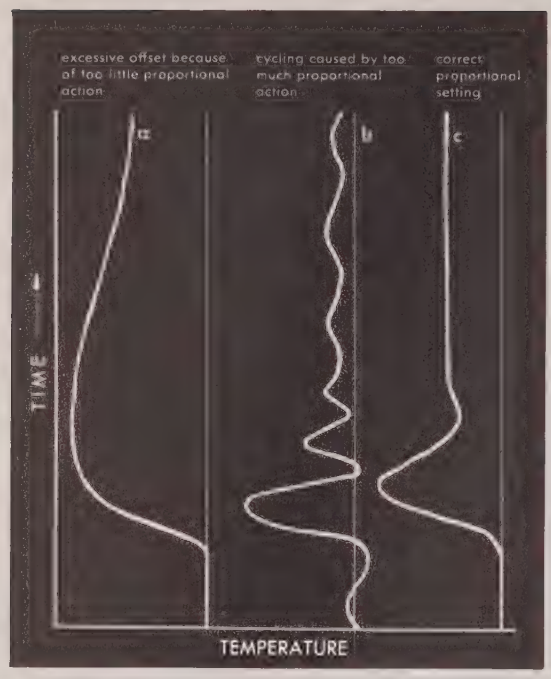
Normally, as rate action is introduced, further increases can be made in proportional action. It is important that this be done in small steps, noting meantime the frequency of any cycling which may develop. If the cycling frequency is about the same as that obtained while initially adjusting the proportional action, there is too much proportional action and it should be decreased, Fig. 9b; if it is appreciably higher, Fig. 9a, the RATE TIME is too long and should be decreased. Correct the amplifier gain setting after each change in proportional action.

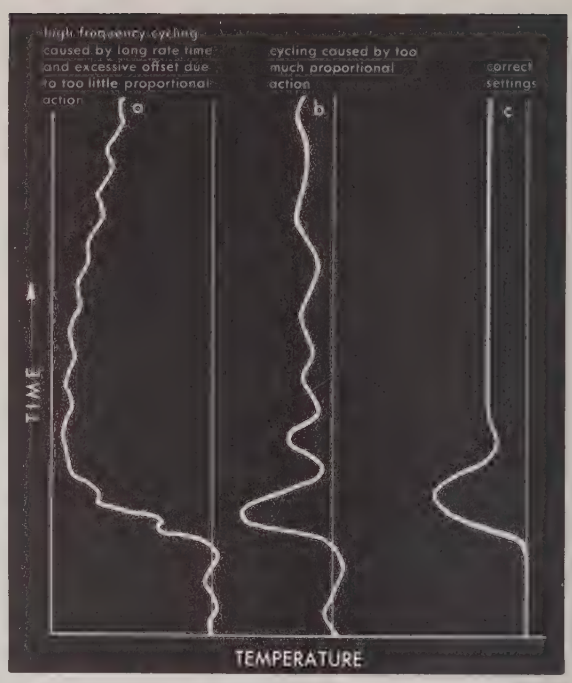
Where instrumentation for a particular process includes more than a single controller, it is advisable to watch the effects of the rate adjustment on other controlled variables. Rate action increases proportional action, and it is possible that small changes in set point for one variable may adversely affect the stability of overall control. Under these circumstances, the RATE TIME setting may have to be decreased substantially, or even reduced to zero.

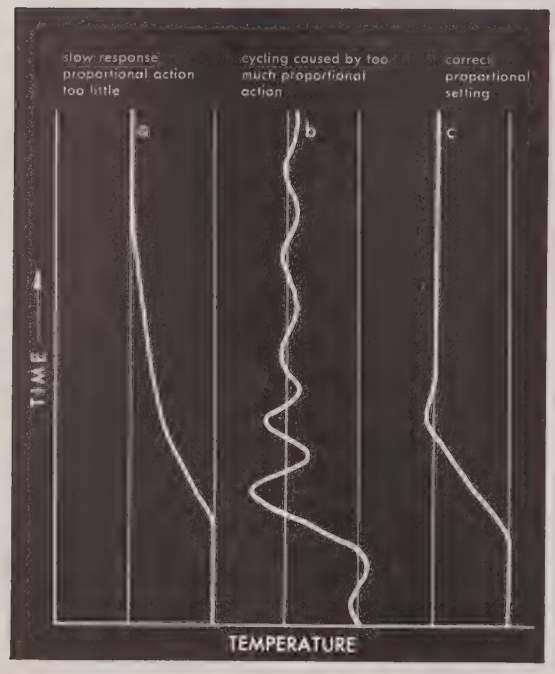
16C. RESET

The RESET dial should be systematically advanced after the proportional and rate adjustments have been made as previously described. As reset action is introduced, the control record again must be carefully observed.

With zero rate action, the appearance of a cycle about the set point, Fig. 10b, considerably slower than that which results from too much

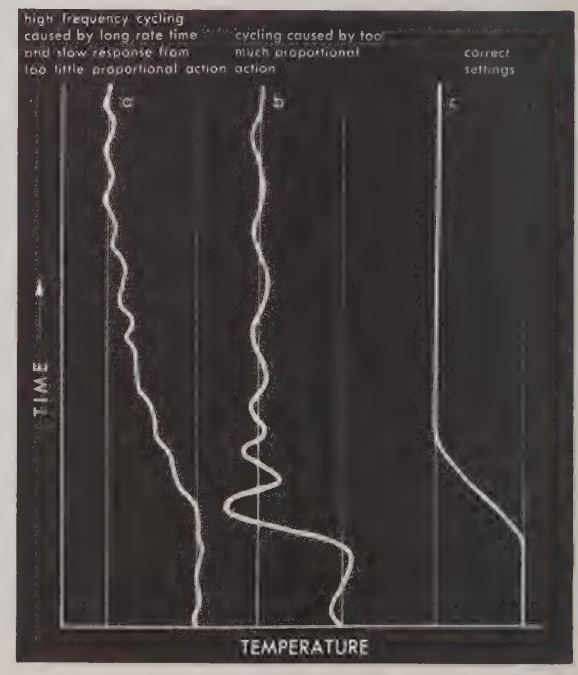






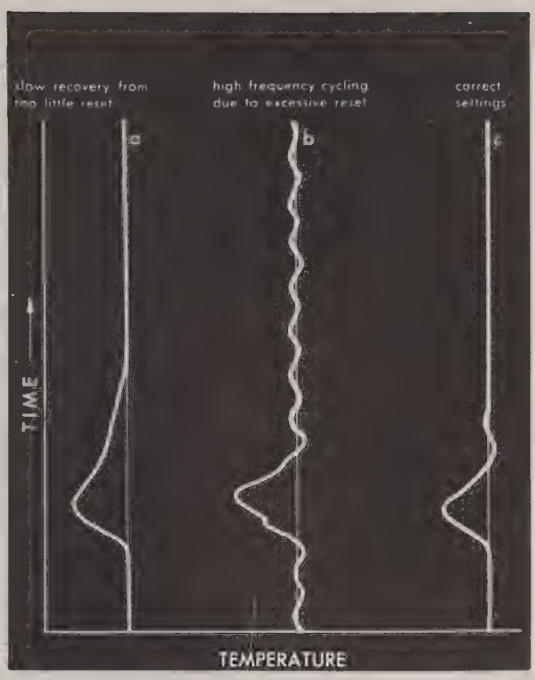
E5534

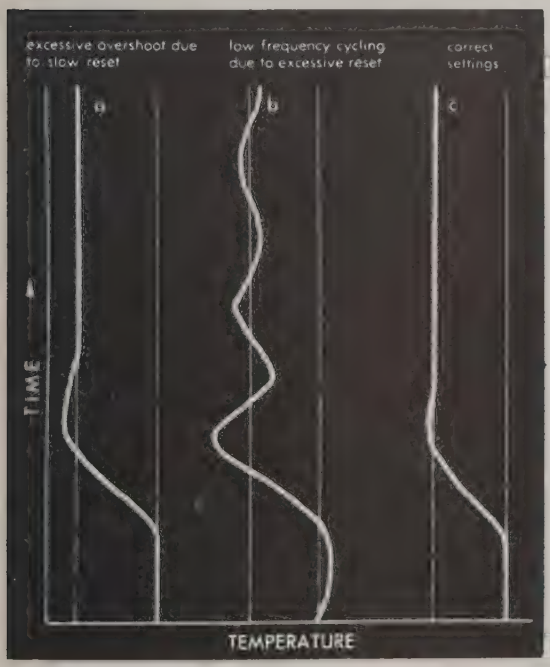
Fig. 8–Curves showing the effects of various proportional settings when no reset or rate action is used. Curves c indicate correct setting(s).



E5535

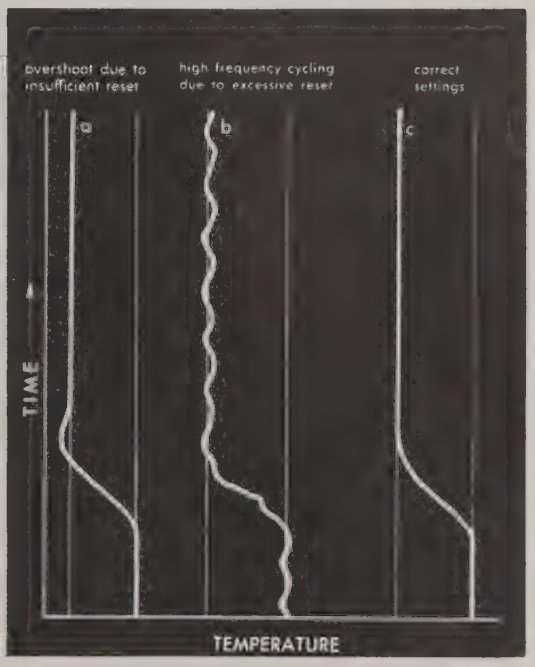
Fig. 9–Curves showing the effects of various rate and proportional settings with a fixed low value of reset. Note that the higher frequency cycling indicates too much rate while the low frequency cycling indicates too much proportional action.





E5536

Fig. 10—Curves showing the effect of various reset control settings when correct proportional action but no rate action is used. Note that the cycle indicating excessive reset is slow when no rate is used.



E5537

Fig. 11—Curves showing the effect of various reset control settings when both proportional and rate action are present. Note the higher frequency cycling for excessive reset when rate is used.

proportional action, Fig. 8b, is a definite indication that the RESET setting is too high and should be reduced.

With rate action, Fig. 11, the cycle may not necessarily be about the set point, and the frequency may be such as to indicate either too much proportional action or too long a rate. The best course to follow in either case is to reduce the amount of reset.

16D. APPROACH

Introduce approach only after proportional band and reset adjustments have been made. The correct approach setting is made experimentally.

Start with a setting of about 50. Observe the return of the controlled variable to the set point. When approach is used, the return of the controlled variable to set point is always a little slower than before. If process response to a change of demand or set point is too slow and sluggish, decrease the approach setting. If this response is so rapid that the controlled variable overshoots the set point, then increase the approach setting. The optimum setting is that which will provide the fastest return to set point with a minimum of overshoot. Note that reset action tends to cancel the effect of approach action as the variable is coming in to set point. Maximum effect of approach action is obtained with minimum reset setting.

16E. Summary of Tuning Instructions

—Adjust proportional action and amplifier gain as high as possible.

—Adjust RATE TIME for maximum minutes.

—Adjust RESET for maximum repeats per minute.

—Eliminate cycling resulting from an incremental adjustment of set point by reducing the adjustment that causes it.

—Compare frequency of cycling resulting from critical adjustment of each of these three actions.

—Eliminate or reduce cycling from one or more causes in order of frequency, starting with the highest frequency.

—Allow sufficient time after each adjustment for the system to stabilize.

—If cycling cannot be completely eliminated, tune for minimum frequency and amplitude.

PART V TECHNICAL INFORMATION

17. CONTROLLER CIRCUIT PRINCIPLES

17A. Basic Operation

A block diagram of a simple P. A. T. process loop is shown in Fig. 12. (See also the Introduction.) The controller produces signals to operate the two-phase motor in a drive unit and thus positions a valve which varies the process input. The controlled variable (temperature, pH, etc.) is measured by a recorder that contains a control slidewire and mechanical set point indicator to produce an error signal or voltage (V_1). This error voltage is derived from a bridge circuit consisting of a slidewire located in the recorder, and two resistors on the controller printed-circuit card, Fig. 13 (or a set point slidewire as for program control). This voltage represents the difference between the desired point of operation (set point) and the controlled variable. When the controlled variable is at the set point, V_1 will be zero.

The basic P. A. T. controller circuit in the automatic mode of operation is shown in Fig. 13. The main components are an FET modulator (chopper), ac amplifier, demodulator, trigger circuits, and triac output stages. The FET chopper stage converts the dc voltage difference between the error signal V_1 and feedback signal V_2 to an ac correction voltage. This signal is fed to an adjustable gain ac differential amplifier which increases the amplitude of the correction voltage. The demodulator senses the polarity of the correction voltage and triggers the appropriate triac circuit to run the drive unit in either direction and thus vary the process input.

The error voltage V_1 may also include a rate signal proportional to the rate of change of the controlled variable. The feedback voltage V_f represents the output of the final control device of the controller. It varies with the voltage at the contact of the drive unit slidewire.

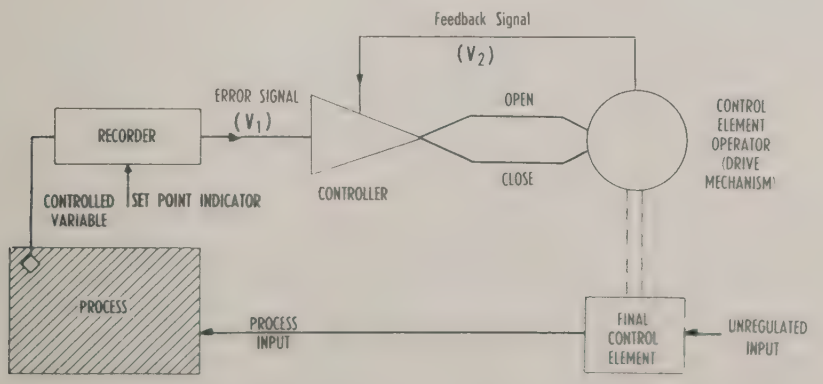


Fig. 12–Basic P.A.T. process loop.

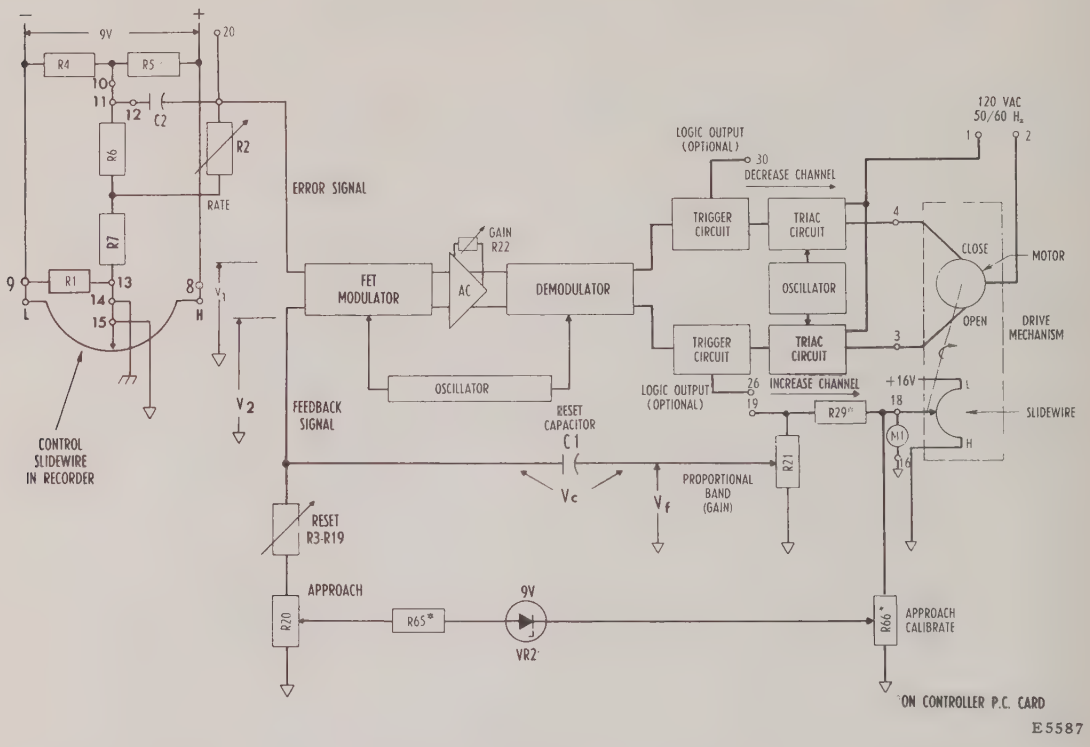


Fig. 13–Simplified schematic of P.A.T. controller in the automatic mode of operation.

With the application of the error and feedback voltages, the controller regulates its output and therefore the process input. Proportional, reset, and rate actions are used so that the departure of the controlled variable from set point can be held to essentially zero. These actions are discussed in the sections that follow.

17B. Proportional Action

When the controlled variable is at the set point, the input (V_1) and feedback (V_2) voltages at the chopper are zero; the controller output is constant. However, when the controlled variable deviates from the set point because of a process load change, a dc error voltage, V_1, is produced at the chopper. The voltage difference between this voltage and feedback signal V_2 is amplified to produce a change in drive unit position proportional to the deviation. The drive unit change adjusts the process input and produces a feedback voltage V_2 which is equal to the error voltage V_1. At this point, the deviation of the controlled variable from set point tends to diminish, owing to the new input from the final control device; consequently V_1 decreases. Thus, as V_1 is reduced, it is tracked by V_2 which is kept equal to V_1, and the final control device adjusts the process input back toward its previous position. To reduce V_1 to zero (at set point), reset action must be added.

17C. Reset Action

In processes where the process input must be continually changing, proportional action alone cannot return the controlled variable to the set point. This can only be done by introducing reset action, which integrates or "repeats" proportional action at a rate determined by the RESET dial setting. Reset action is provided by capacitor C1 and the RESET switch (R3-R20) and is expressed in repeats per minute.

When the controlled variable deviates from the set point, an error voltage V_1 appears at the chopper and the final control device adjusts to produce a feedback voltage V_2 equal in magnitude to V_1, as discussed in the previous section. With resistances R3-R20 connected in series, capacitor C1 is gradually charged to a voltage (V_c) equal to and opposing V_f, the voltage from the arm of the PROPORTIONAL control to common. While C1 is being charged, this charging current flowing through R3-R20 produces the feedback voltage V_2. As this charging current decays, a voltage difference (V_1-V_2) again exists, and the drive unit will adjust the process input the same as before and keep V_2 equal to V_1. When C_1 is fully charged, V_2 goes to zero, matching the V_1 voltage at set point, and the drive unit stops running. If proportional action adjusts the final control device 10% and RESET is set at 1 repeat/minute, the output will be advanced another 10% every minute due to reset action, provided the error voltage has not changed.

To summarize, reset action integrates proportional action at a speed set by the RESET dial.

17D. Rate Action

The effect of rate action is to add a further increment of corrective action proportional to the rate of change of the controlled variable. This action aids or opposes proportional action according to the direction of change.

Rate action is provided by the rate capacitor C2 and the RATE TIME control, R2. It is expressed in minutes, and the dial setting is determined by the ratio of resistance of R6 to R7 and the time constant of R2C2. This is explained in more detail in Section 18A. The setting is the amount of time by which rate action advances the final control element, when compared to the time for the final control element to reach the same output by proportional action alone.

17E. Approach Action

In batch-type processes, where the controlled variable requires a considerable length of time to reach the set point, approach action is used to minimize overshoot during startup. Without approach action, the final control device would normally adjust to the full-on position when the process is started up. The feedback voltage would be constant and capacitor C1 would be charged so that V_c would be equal to V_f, and V_2 would

therefore be zero. Under these conditions, the final control device would not begin to cut back until the controlled variable reached set point ($V_1 = 0$). Due to the inertia of the process, the controlled variable would overshoot.

In order to overcome this difficulty, the APPROACH control applies a fixed voltage to the chopper so that the final control device begins to cut back when the controlled variable is within a certain percentage of recorder scale below set point as established by the APPROACH dial setting (for a 20% slidewire, this is 10% of scale. See Section 3F.).

As seen in Fig. 13, the APPROACH control is part of the Reset resistance and has no other effect upon the circuit when the final control device is below full on or the APPROACH control is at zero. When the final control device has been adjusted to full on, then 9 volts from the approach calibrating potentiometer are applied across the zener diode, and the diode conducts. Under this condition, a fixed voltage, determined by the position of the APPROACH control, appears at the chopper as V_2. This voltage remains until the final control device begins to cut back and the diode stops conducting, at which time the low end of the resistance string returns to the normal reference potential.

The value of V_2 is determined by the setting of the APPROACH dial. If the dial is set at 100, V_2 is nominally 435 mV (with drive unit at open limit). After the process has been started up, the final control device remains full on until the controlled variable is approximately 10% of scale below set point, where V_1 momentarily equals V_2 (at 435 mV). While V_1 continues toward zero, the $(V_1 - V_2)$ difference increases in the opposite direction, causing the final control device to begin cutting back and the correction voltage to decrease. When the approach calibration voltage drops below 9 volts, the zener diode is cut off and the fixed voltage is removed from the low end of the resistance string. Reset action now becomes normal and the circuit functions as discussed previously.

18. CONTROLLER CIRCUITRY

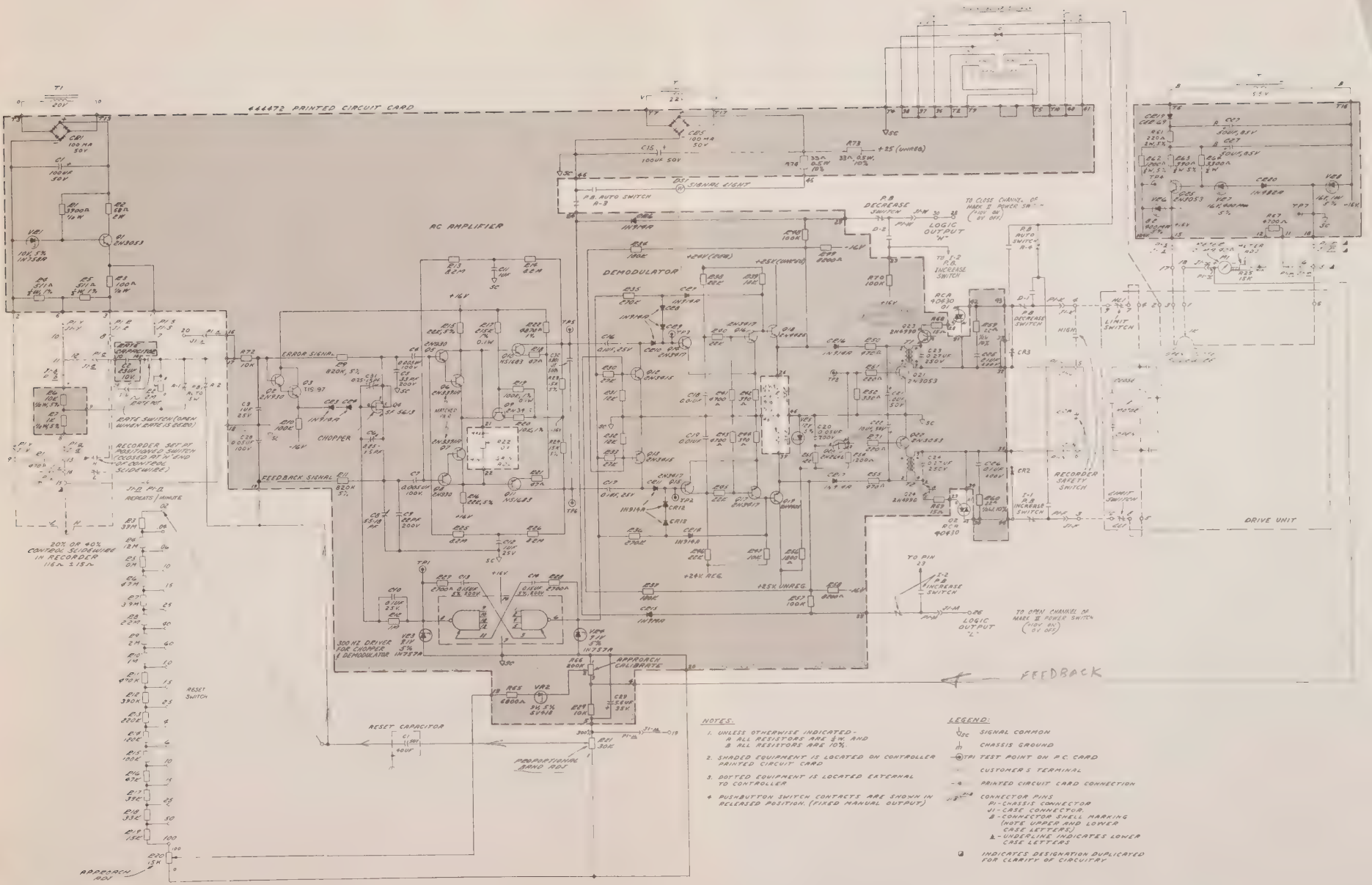
For the following discussion refer to Figs. 13 and 14.

18A. Input Circuit

The total error voltage (V_1) applied to the input circuit of the controller is the sum of two voltages:

(1) An input voltage which is proportional to the deviation of the controlled variable from the set point and whose magnitude is zero when the controlled variable is at set point;

(2) A rate input voltage which is porportional to the speed at which the controlled variable is changing. This magnitude is zero when the controlled variable is not moving.



NOTES:

1. UNLESS OTHERWISE INDICATED -
   A ALL RESISTORS ARE ½W, AND
   B ALL RESISTORS ARE 10%.
2. SHADED EQUIPMENT IS LOCATED ON CONTROLLER PRINTED CIRCUIT CARD
3. DOTTED EQUIPMENT IS LOCATED EXTERNAL TO CONTROLLER
4. PUSHBUTTON SWITCH CONTACTS ARE SHOWN IN RELEASED POSITION. (FIXED MANUAL OUTPUT)

LEGEND:

- SIGNAL COMMON
- CHASSIS GROUND
- TP1 TEST POINT ON P.C. CARD
- CUSTOMER'S TERMINAL
- PRINTED CIRCUIT CARD CONNECTION
- CONNECTOR PINS
  P1 - CHASSIS CONNECTOR
  J1 - CASE CONNECTOR
  B - CONNECTOR SHELL MARKING (NOTE UPPER AND LOWER CASE LETTERS)
  L - UNDERLINE INDICATES LOWER CASE LETTERS
- INDICATES DESIGNATION DUPLICATED FOR CLARITY OF CIRCUITRY

EE5593

Fig. 14—Schematic of 3-Action P.A.T. controller.
See other side for parts list.

PARTS LIST FOR FIG. 14

SYMBOL	DESCRIPTION	L&N PART NO.
R1	Resistor, 3900Ω, 1/2 W, ±10%	011151
R2	Resistor, 68Ω, 2 W, ±10%	311305
R3	Resistor, 100Ω, 1/2 W, ±10%	011132
R4, R5	Resistor, 511Ω, 1/2 W, ±1%	311733
R6	Resistor, 10k, 1/2 W, ±5%	011745
R7	Resistor, 1k, 1/2 W, ±5%	011737
R9, R11	Resistor, 820k, 1/4 W, ±5%	311742
R10, R48, R57, R70	Resistor, 100k, 1/4 W, ±10%	311370
R12	Resistor, 1 M, 1/4 W, ±10%	011931
R13, R14, R25, R26	Resistor, 8.2 M, 1/4 W, ±10%	311511
R15, R16	Resistor, 22k, 1/4 W, ±5%	311580
R17	Resistor, 215k, 0.1 W, ±1%	311688
R18, R21	Resistor, 47Ω, 1/4 W, ±10%	311334
R19	Resistor, 100k, 0.1 W, ±1%	311689
R20	Resistor, 10k, 0.1 W, ±1%	311687
R22	Resistor, 4870Ω, 1/2 W, ±1%	311690
R23, R24	Resistor, 15k, 1/4 W, ±5%	311577
R27, R28	Resistor, 2700Ω, 1/4 W, ±10%	311301
R29, R39, R47, R72	Resistor, 10k, 1/4 W, ±10%	011773
R30, R33	Resistor, 27k, 1/4 W, ±10%	311257
R31, R32, R53	Resistor, 12k, 1/4 W, ±10%	311259
R34, R37	Resistor, 180k, 1/4 W, ±10%	311379
R35, R36	Resistor, 270k, 1/4 W, ±10%	311261
R38, R40, R45, R46	Resistor, 22k, 1/4 W, ±10%	011771
R41, R43, R67	Resistor, 4700Ω, 1/4 W, ±10%	311112
R42, R44	Resistor, 390Ω, 1/4 W, ±10%	311725
R49, R58	Resistor, 8200Ω, 1/4 W, ±10%	311297
R50, R55	Resistor, 470Ω, 1/4 W, ±10%	011765
R51, R71	Resistor, 220Ω, 1/4 W, ±10%	311113
R52	Resistor, 330Ω, 1/4 W, ±10%	311723
R54	Resistor, 1200Ω, 1/4 W, ±10%	311293
R56	Resistor, 1.8k, 1/4 W, ±10%	311722
R59, R60	Resistor, 22Ω, 1/2 W, ±10%	011124
R61	Resistor, 220Ω, 2 W, ±5%	011991
R62	Resistor, 1200Ω, 1/2 W, ±5%	011655
R63	Resistor, 390Ω, 1/2 W, ±5%	011734
R64	Resistor, 3300Ω, 1/2 W, ±10%	011150
R65	Resistor, 6800Ω, 1/4 W, ±10%	011770
R66	Potentiometer, 200k, 1/2 W, ±10%	013472
R68, R69	Resistor, 15Ω, 1/4 W, ±10%	311724
R73, R74	Resistor, 33Ω, 1/2 W, ±10%	011126

SYMBOL	DESCRIPTION	L&N PART NO.
C1, C15	Capacitor, 100 μF, 50 wVdc	023676
C2	Capacitor, 23 μF, 10 wVdc	023677
C3, C11, C12	Capacitor, 1 μF, 25 wVdc	023415
C4, C7	Capacitor, .005 μF, 100 wVdc	023291
C5	Capacitor, 33 pF, 200 wVdc	023675
C6, C31	Capacitor, Trimmer 0.25-1.5 pF	023679
C8	Capacitor, Adj 55-18 pF	023680
C9	Capacitor, 22 pF, 200 wVdc	023674
C10, C16, C17	Capacitor, .1 μF, 25 wVdc	023519
C13, C14	Capacitor, .15 μF, 200 wVdc	023671
C18, C19	Capacitor, .01 μF, 50 wVdc	023451
C20	Capacitor, .05 μF, 400 wVdc	023038
C21, C22	Capacitor, 10 μF, 50 wVdc	023684
C23, C24	Capacitor, .27 μF, 250 wVdc	023584
C25, C26	Capacitor, .1 μF, 400 wVdc	023793
C27	Capacitor, 50/50 μF, 85 wVdc	023686
C28	Capacitor, .05 μF, 100 wVdc	023289
C29	Capacitor, 5.6 μF, 35 wVdc	023673
C30	Capacitor, .001 μF, 500 wVdc	023097
Q1, Q21, Q22, Q25	Transistor, 2N3053	188173
Q2	Transistor, 2N930	188304
Q3	Transistor, TIS97	188188
Q4	Transistor, SF5613	188252
Q5	Transistor, 2N930	188304
Q6, Q7	Transistor, 2N3391A (matched pair)	188257
Q8	Transistor, 2N930	188304
Q9, Q12, Q13	Transistor, 2N3415	188221
Q10, Q11	Transistor, NS1683	188244
Q14, Q15, Q16, Q17	Transistor, 2N3417	188182
Q18, Q19	Transistor, 2N4425	188254
Q20	Transistor, GED5E43	188229
Q23, Q24	Transistor, 2N4990	057201
CR1, CR5	Diode, Full Wave Bridge	057115
CR3, CR4, CR6-CR17	Diode, 1N914A	188056
CR19	Diode, 750 mA, 200 V	057028
CR20	Diode, 1N482A	057046
VR1	Zener Diode, 1N758A	188126
VR2	Zener Diode, SV418	188115
VR3, VR4	Zener Diode, 1N757A	188032
VR5	Zener Diode, 1N963B	057200
VR6	Zener Diode, 1N756	057178
VR7, VR8	Zener Diode, 16 V, 1 W, ±5%	057141
IC1	Integrated Circuit (MC660P)	193203
T1, T2	Transformer (Pulse)	019267

The error voltage is developed when the input bridge circuit of the controller becomes unbalanced as a result of a change in the controlled variable. Resistors R4 and R5 (or a set point slidewire) form one leg of the bridge while the control slidewire in the recorder is the other leg. A 9-volt (nominal) power supply in the controller is connected across the bridge. The difference in voltage between the two legs of the bridge is the error voltage, and is applied across resistors R6 and R7. When the bridge is balanced, the error voltage is zero. If the controlled variable increases so that the arm of the slidewire moves toward the "H" side, the bridge becomes unbalanced and a negative error signal is produced. If the slidewire changes so that the arm moves toward the "L" side (decreasing controlled variable), a positive error signal results.

Resistors R6 and R7 form the rate gain network. The rate voltage is the voltage across R6 and is applied to the rate capacitor C2. The voltage across R7 is the proportional voltage and is added to the rate voltage to form the single error signal V_1 with respect to the circuit common. C2 is charged at a rate dependent upon the rate control R2. When R2 is in the off position, the charging path to C2 is open and the rate control is shorted. The rate time is determined by the time constant of R2C2 and the ratio of resistance of R6 to R7 in the rate gain network. Since R6 is 10K and R7 is 1K, the rate gain is 10 and the maximum rate time is RATE GAIN x R2 x C2 = 10 x 23 μF x 2 megohms = 460 seconds or 7.7 minutes ±20%.

18B. Feedback and Reset Circuit

The feedback voltage V_f is developed across the proportional band control R21 from the position of the drive unit slidewire. A fraction of this voltage (V_2) is connected to the FET chopper through the reset capacitor C1. C1 and reset resistors R3 to R20 provide reset action. The reciprocal of their time constant is equal to the number of repeats per minute (e.g., when maximum RC = 75 megohms x 40 μF = 3000 seconds = 50 minutes, the number of repeats is 1/50 = .02 per minute ±20%).

18C. Chopper (Modulator)

The error signal V_1 and feedback signal V_2 are applied to the FET chopper stage through resistors R9 and R11 respectively, Fig. 14. The chopper employs a field effect transistor (FET), Q4, as the switching element, and is driven at a frequency of approximately 330 Hz. (See Section 18D.) Transistors Q2, Q3 and diodes CR2-CR4 are used to set the proper gate switching level for Q4. The chopper converts the dc difference voltage between V_2 and V_1 to a square wave which is coupled to the ac differential amplifier through capacitors C4 and C7. Capacitors C6 and C8 are factory tuned to eliminate the commutating transient spikes caused by the switching of Q4.

18D. Oscillator (Modulator and Demodulator Driver)

The oscillator used to switch the FET chopper is a cross-coupled,

dual-gate logic package, IC1. The outputs are cross-coupled to the inputs through RC combinations (R27/C13, R28/C14, Fig. 14) to produce an astable multivibrator. Zener diodes VR3 and VR4 are used to clip the signal at 9 volts and thus "square up" the waveform. The resulting signal is a square wave whose frequency is about 330 Hz. The output is coupled to the FET gate through capacitor C10. This oscillator is also used to drive the demodulator which is discussed in Section 18F.

18E. AC Amplifier

Transistors Q5 through Q11, Fig. 14, comprise a two-stage, direct-coupled, adjustable-gain differential amplifier. The input stages are connected in a Darlington configuration to achieve a high input impedance. Dc feedback is used around the entire amplifier to obtain good temperature and operating stability. The gain is adjusted by potentiometer R22. Transistor Q9 provides a constant current source to the Darlington stages. The differential output is applied to the demodulator through capacitors C16 and C17.

18F. Demodulator

Transistors Q12 and Q13, Fig. 14, form the demodulator for the controller. The transistors operate together as a half-wave rectifier and in this manner convert the ac square wave to a unipolar signal. The bases of the transistors are driven in phase with respect to each other by the 330 Hz oscillator. The oscillator phasing is arranged so that a positive error signal to the chopper (representing a decreasing controlled variable) causes a positive output signal at the collector of Q13 and a negative output signal at Q12 and vice versa. With zero error signal, both collectors will be at 0 volt.

The collector signals are connected through CR10 and CR11 to the bases of the trigger circuits. The oscillator signal is also connected to these bases through R35, CR8 and CR9, and R36, CR12 and CR13. This phasing is arranged so that a constant positive dc level is produced at the trigger base that is connected to the demodulator collector with a positive signal present.

18G. Trigger Circuits

There are two identical channels forming the trigger circuits, i.e., one for increase and one for decrease operation of the drive unit. Q14 and Q16 are connected as a Schmitt trigger circuit in the decrease channel (top channel in Fig. 14); Q15 and Q17 perform the same function in the increase channel. The Schmitt trigger will only respond to a positive signal greater than about 1.6 volts. This level signal will turn the trigger on and give +24 volts at the collector of Q16 or Q17. The trigger will remain on until the input base voltage drops to approximately 1.6 volts again. At this point the collector voltage at Q16 or Q17 will decrease to about 0.9 volt.

When the error signal to the controller is zero, the voltage at the input to the Schmitt triggers will not be enough to turn them on. The collectors of Q16 and Q17 (and hence the emitters of Q18 and Q19) will be at a low potential and the signal lights in each channel will be dark. This voltage will be sufficient to prevent Q21 and Q22 from turning on and producing a pulse to trigger the triacs as explained in Section I.

With a positive error signal at the chopper, a positive signal will appear at the collector of Q13 and a negative signal at the collector of Q12. The Schmitt trigger on the decrease channel will not respond to the negative signal and the voltage at the Q16 collector will be low. The triac in this channel will not be triggered and the red signal light DS2 will be dark. The positive level at the base of Q15 in the increase channel will produce 24 volts at the Q17 collector and a high voltage (approximately 23 V) across the yellow signal light DS3. This will illuminate the yellow light and trigger triac Q2. The drive unit will run to the open position.

A negative error signal to the chopper will interchange the operation of the channels and cause the drive unit to run to the closed position.

Resistors R34 and R37 are used for interlocking so that simultaneous operation of the two channels cannot occur.

18H. Triac Oscillator Circuit

A unijunction transistor (Q20) oscillator circuit is used to drive the bases of Q21 and Q22 and produce a pulse to turn on the appropriate triac if a trigger voltage is present. The unijunction is connected as a relaxation oscillator with the frequency (1.5 kHz) determined by R53 and C20. The oscillator output pulse is taken across R52.

18I. Triac Circuit

When 24 volts is present at the collector of either Q21 or Q22, a pulse will be coupled to the secondary of pulse transformer T1 or T2 by the switching of Q21 and Q22. This pulse will appear at the gate of the triac and trigger it on. This will cause the drive mechanism to operate. Q23 and Q24 are silicon unilateral switches (S.U.S.) which do not conduct until a certain threshold voltage is reached. These are used to prevent random noise signals from triggering the triac. The RC (R59 and C25, and R60 and C26 in increase channel) circuits at the triac outputs act as a filter to prevent any rf interference or high-voltage changes across the triac. These also provide starting current to "latch" on the triac.

Diode CR1 (Thyrector) is used as a surge protector across the ac line to prevent any high line transients from damaging the triac switching circuit. It acts as an open circuit until a voltage greater than approximately 150 volts appears across its terminals at which time it appears as a short circuit.

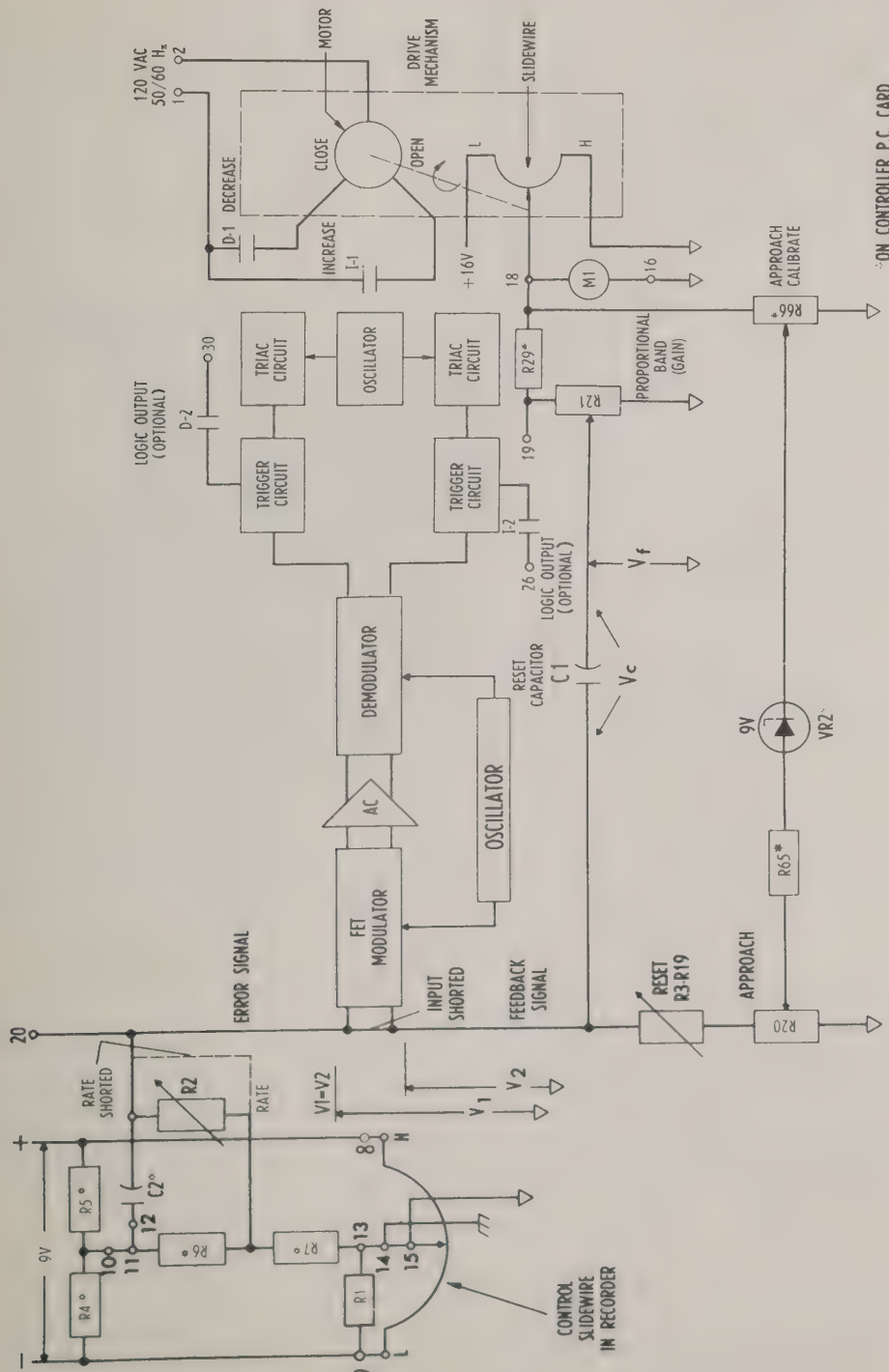


Fig. 15–Simplified schematic of P.A.T. controller in the manual mode of operation.

18J. Logic Output (Optional)

A logic output is available from each channel to trigger an external power switch arrangement. The output is taken at the emitter of Q18 or Q19 through R48 or R57. When a channel is turned on, a +24 volt logic signal is produced. An off condition will result in a 0.5 volt output.

18K. Power Supplies

The controller has three separate power supplies which operate from the three secondary windings of T1.

The 55-volt winding supplies the +16, +24, and -16 dc voltages (regulated) for the controller circuitry.

The 20-volt winding produces approximately 9 volts dc (regulated) to supply the input bridge circuit.

The 22-volt winding is used to obtain approximately 25 volts dc (unregulated) to operate the unijunction oscillator and the signal lights.

18L. Manual Operation

The circuit of the P.A.T. controller in the manual mode of operation is shown in Fig. 15. The drive unit is now isolated from the error signal and trigger paths and is operated directly by the DECREASE (D-1) and INCREASE (I-1) pushbutton switch contacts. The logic output is obtained through the D-2 and I-2 contacts.

(1) Transfer from AUTO to MAN Operation

When switching from AUTO to MAN, the drive unit will remain at the same position on MAN as on AUTO and there will be no bump in the process input. The drive unit position will remain constant until the INCREASE or DECREASE button is operated.

(2) Transfer from MAN to AUTO Operation

On manual operation the input to the chopper is shorted and hence the error signal V_1 equals the feedback signal V_2. The reset capacitor C1 charges to a voltage equal to the difference between the error voltage and the proportional feedback voltage V_f. The voltage V_f follows the drive unit position and thus V_c tracks the error signal and process input. This allows for a bumpless transfer from manual to automatic operation.

PART VI SERVICING AND TROUBLESHOOTING

19. GENERAL INFORMATION

To determine the probable source of trouble in a control loop, it is best to initially check the operation of the basic components of the loop independently. This approach will localize the trouble to one of these components. Procedures for troubleshooting the basic components are covered in instructions supplied with them.

In the event of faulty controller operation, the trouble can often be eliminated simply by substituting another chassis assembly of the same type. Thus it is advisable to stock a spare chassis assembly (L&N Part No. 173050, Table I). If a spare controller is not available, refer to the troubleshooting procedures which follow to ascertain whether the fault lies with the printed-circuit card or with chassis mounted components. If the printed-circuit assembly is found to be defective, it is recommended that the assembly be removed from the chassis assembly (see Section 22) and returned to L&N for repair. A spare card can then be substituted. Field servicing of these circuit card assemblies is not recommended since cards and components can be severely damaged through improper soldering and handling techniques. Chassis mounted components can be replaced as described in Section 24.

Fig. 16 shows circuit card pin voltages and waveforms for the conditions indicated. Fig. 14 is the schematic of the controller, and Fig. 17 shows cable routing through the unit. Fig. 18 is the parts list and includes spare parts to be carried on hand.

20. TEST EQUIPMENT

The following three equipment items are recommended for testing the controller.

(1) Volt-Ohmmeter

A volt-ohmmeter is required for checking resistances and voltages in the controller. A meter having 1000-ohms-per-volt impedance on the ac ranges and 20,000-ohms-per-volt impedance on the dc ranges is suitable for this purpose. The Simpson Model 260 has the required characteristics. If a lower impedance voltmeter is used in measuring voltages across high resistance circuits, lower readings must be expected, and conversely.

(2) Oscilloscope

For observing the waveforms indicated in Fig. 16, the oscilloscope should have a vertical amplifier sensitivity of 5 mV/cm and a sweep rate of 1 ms/cm.

(3) Special Test Equipment

No. 127834 service shelf attaches to the plug-in socket of the controller and forms a convenient table on which to place the chassis for testing. It is available from Leeds & Northrup Company.

21. TROUBLESHOOTING

Procedures for tracing faults to the chassis and printed-circuit assemblies are given in Sections 21A and 21B. If the fault lies in the chassis assembly, refer to the instructions given in Section 21B to determine the defective component. If the printed-circuit card is defective and no spare is on hand, analyze the circuit in conjunction with the voltages and waveforms given in Fig. 16 to determine the defective component. See Section 23 for the proper removal and replacement of printed-circuit-card components.

All voltages and waveforms should be measured for the conditions given in Fig. 16. The rear terminal board should be temporarily modified to correspond to these conditions if different installation connections are being used.

21A. Procedure

(1) If line fuses blow when replaced, remove the chassis from the case and make the following checks:

(a) Check Thyrector CR1 as explained in Section 21B, step (8).

(b) Check for a short circuit between chassis and case of the triacs, with an ohmmeter (R x 10,000 range). Resistance should be infinite.

(2) Measure voltages and waveforms at pins 15, 45, T16, TP1, TP4, and TP8, and between pins 1 and 2 as shown in Fig. 16. If correct voltages and waveforms are not obtained, proceed to step (3) below. If correct voltages are obtained, proceed to step (4).

(3) Measure line voltage across Thyrector CR1, between outer terminals of terminal strip mounted under power transformer. Measure voltages between T6 and T16, T7 and T17, and T3 and T13, as shown in Fig. 16. If correct voltages are obtained, a component on the card is probably defective. If incorrect voltages are obtained, turn off power and remove the wires from pins T6 and T16. With power on measure the ac voltage between the two blue transformer leads. Replace the leads when finished. Repeat for T7-T17 leads (violet) and then T3-T13 (orange). If correct voltages are obtained, a component on the card is defective. If incorrect voltages are obtained, the transformer is defective.

(4) Check the remaining circuit card pins and test points as shown on Fig. 16. Then move the control slidewire contact to the low end of the

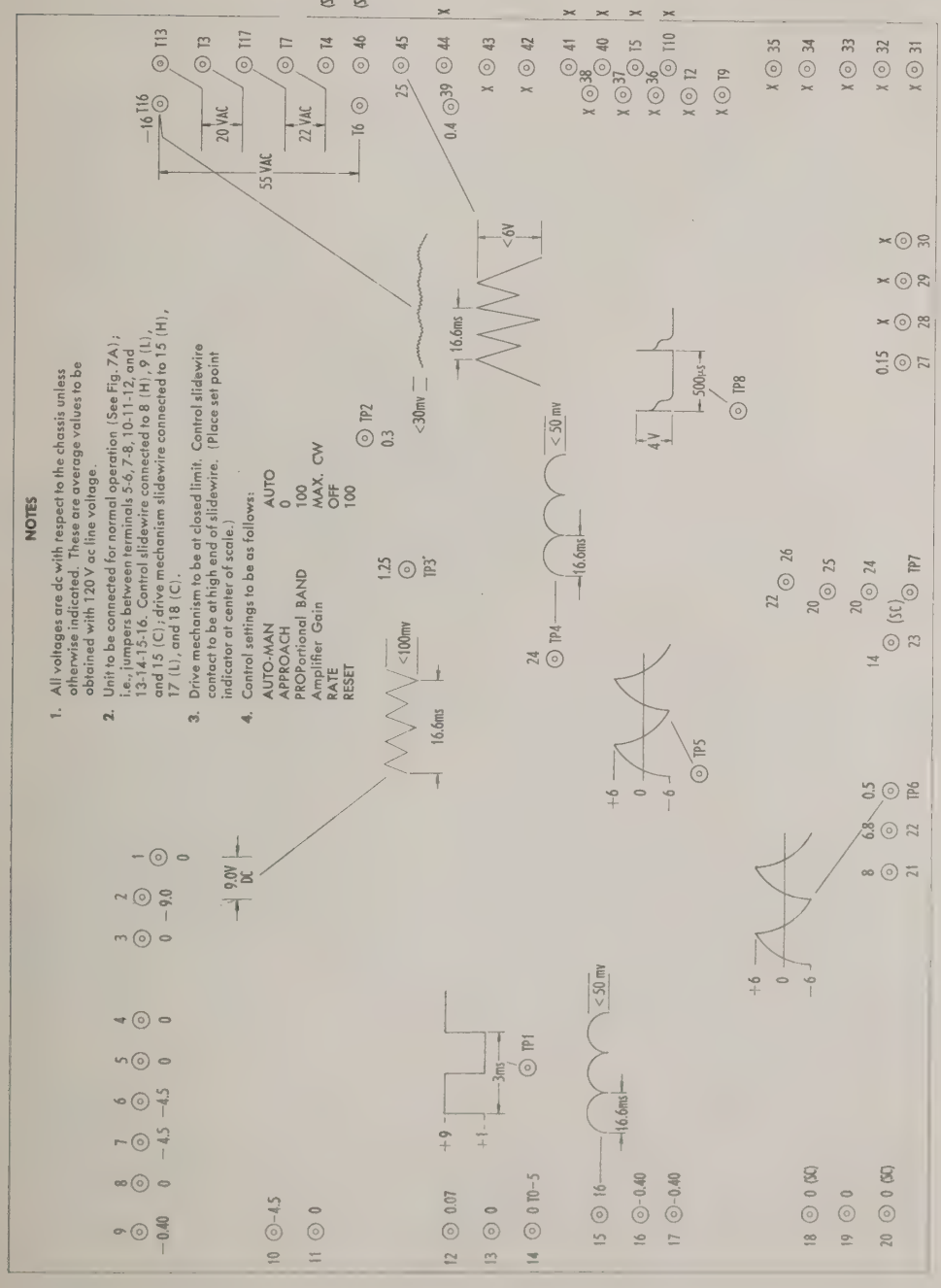

NOTES
1. All voltages are dc with respect to the chassis unless otherwise indicated. These are average values to be obtained with 120 V ac line voltage.
2. Unit to be connected for normal operation (See Fig. 7A); i.e., jumpers between terminals 5-6, 7-8, 10-11-12, and 13-14-15-16. Control slidewire connected to 8 (H), 9 (L), and 15 (C); drive mechanism slidewire connected to 15 (H), 17 (L), and 18 (C).
3. Drive mechanism to be at closed limit. Control slidewire contact to be at high end of slidewire. (Place set point indicator at center of scale.)
4. Control settings to be as follows:
AUTO-MAN AUTO
APPROACH 0
PROPortional BAND 100
Amplifier Gain MAX. CW
RATE OFF
RESET 100
9.0V DC
55 VAC
20 VAC
22 VAC
<100mv
16.6ms
1.25
TP3
<30mv
<6V
<50 mv
4 V
500μs
TP1
TP2
TP4
TP5
TP6
TP7
TP8
T3
T4
T5
T7
T10
T12
T13
T17
T16
X—Because of close spacing and the presence of line voltage, these pins are not to be measured.
SC—Indicates signal common.
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Fig. 16—Printed-circuit-card voltage and waveform test points.

slidewire and manually set the drive mechanism at the open limit. Check voltages in accordance with the following table:

PIN NUMBER	NORMAL INDICATION
3	+9.0
4	+16
5	+12
6	+4.5
7	+4.5
9	+0.40
10	+4.5
16	+0.40
17	+0.40
25	+0.15
26	+0.40
27	+20
39	+22
TP2	+1.20
TP3	+0.35

If the proper values are not obtained in Fig. 16 or the above table, the fault may be in either the card or the chassis assembly. Analyze the schematic, Fig. 14, to determine which sections of the circuit are involved. If chassis mounted components are involved, these can be checked by referring to Section 21B.

The remaining tests below cover checking various sections of the circuit to assist in localizing the fault.

(5) Slidewire Input Circuit Check

Turn the recorder off. Then disconnect the white wire from pin 9. The dc voltage between pin 9 and the chassis should vary between −0.4 volt (slidewire contact at high end) and +0.4 volt (slidewire contact at low end) as the control slidewire in the recorder is moved over its full range. If incorrect voltage is obtained, check the recorder slidewire connections, and resistors R6 and R7 on the printed-circuit card. These resistors can be checked with an ohmmeter by removing the wires from pins 7 (violet) and 9 (white) and measuring across the resistors.

(6) Rate Capacitor Check

Remove the wires from pins 10 and 14. Connect an ohmmeter (R x 10,000 range) across pins 10 and 14. The meter should initially kick toward zero ohm and then slowly increase its resistance reading. The final value should be greater than 5 megohms.

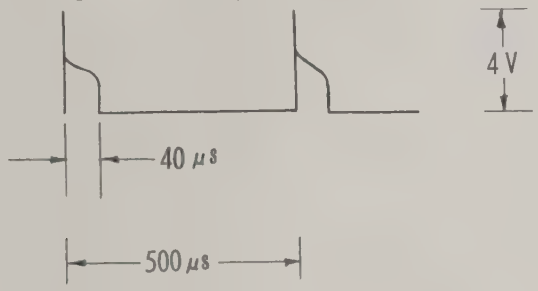
(7) Chopper and AC Amplifier Check

See Section 25B—Steps (1), (2), and (3). Also, dc voltage between

TP6 and the chassis should be −1 to −3 volts. If the correct dc voltage is obtained but not proper waveforms, the fault is probably in the chopper circuit.

(8) Triac Circuit Check

If all voltage and waveforms appear to be correct but the drive unit will not run properly on AUTO, the triac(s) may be at fault. To check the Q1 triac (top triac) for an open circuit, turn off power to the controller (or remove the controller from the case) and disconnect the violet wire from pin 37. Connect an oscilloscope between pin 28 (probe) and pin 32 (ground). Set the oscilloscope vertical sensitivity on 1 V/cm and the sweep rate on 100 microseconds/cm. Set the controller and slidewire for the conditions in Fig. 16. Connect power to the controller. The waveform should be approximately as follows:



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If the above waveform is obtained but the drive unit will not run closed, Q1 is probably defective. If the waveform is not obtained, there is a fault in the preceding stages. Check for a shorted triac by removing the chassis from the case and then disconnecting the wires from pins 31 (brown) and 42 (red). Measure the resistance between the brown and red wires. Resistance should be infinite.

Q2 can be checked for an open circuit by moving the control slidewire contact to the low end of the slidewire and manually setting the drive mechanism to the open limit. Turn off power to the controller (or remove the controller from the case) and connect the oscilloscope between pins 29 (probe) and 35. The violet wire should still be disconnected from pin 37. Apply power and check for the waveform above. Check for a shorted triac by removing wires (with chassis removed from case) from pins 34 and 30 and measuring the resistance between the yellow and black wires as above.

21B. Checking Chassis Mounted Components

The following tests are performed using an ohmmeter (see Section 20) with the controller disconnected from the case.

(1) Reset Capacitor: Unsolder the capacitor lead connected to the middle terminal of the PROPortional BAND potentiometer. Connect the ohmmeter (R x 10,000 range) across the capacitor. The meter should

kick toward zero ohm and then slowly increase its resistance reading. The final reading should indicate greater than 5 megohms. Leave the capacitor unsoldered for (2) below.

(2) Reset Switch: Disconnect the wire from pin 19. The reset capacitor lead connected to the middle terminal of the PROPortional BAND potentiometer should be disconnected from (1) above). Depress the AUTO pushbutton and set the RESET dial at .02. Connect the ohmmeter (R x 10,000 range) between the 100 terminal (brown wire) of the APPROACH potentiometer (see Fig. 14) and the white wire that was connected to pin 19. Resistance should be approximately 75 megohms (negligible reading on Simpson Model 260 meter). Set the RESET dial at 1.0. Resistance should be 1.5 megohms. Set the RESET dial at 10. Resistance should be 150K ohms. Resolder the capacitor lead removed in step (1) above.

(3) Proportional Band Potentiometer: Disconnect the wires from pins 19 and 5. Resistance from the center terminal of the potentiometer to pin 20 should vary from 0 to 30K ohms.

(4) Approach Potentiometer: Disconnect the wires from pins 19 and 5. Set the RESET dial at .02. Resistance from the center terminal to pin 20 should vary from 0 to 15K ohms.

(5) Rate Potentiometer: Disconnect the wires from pins 14, 10, and 17. With AUTO button depressed, the resistance from the center terminal to the violet wire that was connected to pin 17 should vary from 0 to 2 megohms.

(6) Amplifier Gain Control: Disconnect the wires from pins 21 and 22. Resistance across the potentiometer should vary from 0 to 10K ohms.

(7) Meter Adjust Potentiometer: Disconnect the wire to pin 12. Resistance across the potentiometer should vary from 0 to 15K ohms.

(8) Thyrector: Disconnect the wires from pins 38 (gray) and 41 (brown). Connect an ohmmeter (R x 10,000 range) between the gray and brown wires. Resistance should be greater than 250K ohms.

(9) Output Meter: Remove the leads from the meter. Set the ohmmeter on the R x 10,000 range only. Connect the ohmmeter across the output meter with the positive ohmmeter lead on the top terminal of the output meter. The output meter should deflect about 5 divisions. Do not switch the ohmmeter to the R x 100 or R x 1 range or the output meter movement may be damaged.

22. REMOVING PRINTED-CIRCUIT ASSEMBLY FROM CHASSIS ASSEMBLY

The printed-circuit card is held to the chassis by 4 "snap on" Teflon spacer bushings. To remove the card, first remove all push-on wire

connections to the card. Then remove the two screws holding the 41-pin connector at the rear of the chassis. Place a pencil or finger through the access holes on the chassis sides and push upwards to release the card from the Teflon spacers. Be careful not to damage the circuit foil while doing this. With the board released, it will be possible to slide the card out of the chassis. In some cases, it may be necessary to also remove the four screws holding the chassis to the front panel in order to manipulate the card past the cabling.

To replace the card, first center the card so that a spacer bushing is lined up with each mounting hole. Then press down the card in the region around each spacer until the card is snapped into place. Be careful not to damage nearby components.

It should be observed that the push-on leads to the printed-circuit card are color coded with respect to the pin numbers. The last digit of each pin number corresponds to the standard component color coding; i.e., a brown wire is connected to pins 1, 11, 21, 31, a red wire is connected to pins 2, 12, 22, etc. A "T" designation indicates power transformer leads. Refer to Fig. 17 if necessary.

23. SERVICING THE PRINTED-CIRCUIT CARD

Whenever a defective part has been located on the printed-circuit card, it can be removed by unsoldering it from the foil side of the card with a small-tip, low-wattage soldering iron. Unsolder as quickly as possible to prevent heat from loosening the copper foil, and make sure that solder does not obstruct the mounting holes for the replacement part. Insert the leads of the replacement part through the holes and bend them slightly on the foil side, cut off the excess wire, and solder the part in place. The soldered joints should not be more than 1/16-inch above the card surface.

24. REPLACING CHASSIS MOUNTED COMPONENTS AND LAMPS

When faulty parts on the chassis are replaced, the new parts and wiring should conform to the original arrangement. When resoldering, use no more solder than necessary to produce a satisfactory connection.

To replace a burned-out lamp, first remove the chassis from the case. Then pull off the pushbutton and lift out the faulty lamp from between the retaining clips. Install a new lamp by reversing this procedure.

25. RESETTING FACTORY ADJUSTMENTS

25A. Approach Calibration

Calibration of the approach circuit is a factory adjustment. Recalibration is normally required only when the drive unit limit switches are changed, or when zener diode VR2 or an associated component is replaced. If necessary to recalibrate this circuit, use the method given below, which requires no connections or disconnections to be made.

The APPROACH CALIBRATE potentiometer (R66, Fig. 14) is located on the printed-circuit card, Fig. 5, and is to be adjusted while the unit is energized; therefore, it will be necessary to use the extension shelf, L&N Part No. 127834, to adjust the potentiometer with the chassis on the shelf in front of the case.

(1) Release the AUTO pushbutton by momentarily depressing the yellow pushbutton, putting the controller on manual control while the dial settings are being made. Set the APPROACH to 100, the PROPortional BAND to 10% (Prop. Gain 10), RATE TIME to OFF, and RESET to 100.

(2) Establish an error signal of about −4.5 volts. The most convenient way to do this is to turn off the recorder and manually turn the control slidewire until its contact is at the low end of its travel. This condition exists when the measuring pointer is below the set point indicator by 10% of the scale for the 20% slidewire or by 20% for the 40% slidewire. To establish a −4.5 V error signal with a 100% control slidewire with the rate action circuit connected, set the recorder at the low end of its scale and the set point slidewire at 50% of scale. With rate action disconnected at the terminal board, set the recorder at the low end and the set point slidewire at 20% of scale.

(3) Turn the APPROACH CALIBRATE potentiometer fully CCW.

(4) Depress the AUTO button and allow the drive unit to reach a limit.

(5) Slowly adjust potentiometer R66 CW until the drive unit just begins to move.

(6) To check operation of the approach circuit, turn the APPROACH dial to 50, then turn the RESET dial to .02. Manually turn the control slidewire and note that the drive unit begins to move when the pointer is midway between the starting point and the set point indicator.

(7) If the drive unit begins to move too soon, move R66 slightly CCW, turn RESET to 100, and repeat step (6). If the drive unit moves after the midway point is reached, move R66 slightly CW, turn RESET to 100, and repeat step (6).

25B. Chopper Tuning Adjustment

This adjustment should require attention only if a component in the chopper or ac amplifier is changed. It will be necessary to use the extension shelf, L&N Part No. 127834, and an oscilloscope (see Section 20) for this operation. The adjustment is made with the controller on manual control and no external connections other than the oscilloscope are required. The two trimmer capacitors to be tuned, C6 and C8, are located on the left-hand front corner of the printed-circuit card, Fig. 5. The adjustment should be made using an insulated type tuning wand (such as JFD #7104-5 or #5284). Do not use a metal screwdriver.

Proceed as follows:

(1) Place the controller on manual control.

(2) Connect an oscilloscope between TP6 (probe end) and TP7 (ground). Set the oscilloscope vertical amplifier sensitivity at 5 volts per cm. Set the sweep rate at 1 millisecond per cm. Set triggering for + internal. (It may be necessary to trigger the oscilloscope externally from TP1.)

(3) A properly tuned chopper will produce a flat square wave (amplitude about .5 volt) free from spikes at TP6:

(4) To retune use the insulated tuning tool and adjust capacitors C6 and C8 as follows:

(a) Tune C8 for maximum flatness (minimum amplitude) of signal waveform. Disregard spikes.

(b) Tune C6 for minimum spike amplitude or until spikes disappear.

(c) Tune C8 for maximum flatness of signal.

(d) Tune C6 for minimum spike amplitude.

(e) Tune C8 for maximum flatness of signal.

(f) Tune C6 for maximum flatness of the signal. Do not turn the adjustment screw all the way out. If the signal is not completely flat when the screw is about 3 turns from the end, stop and proceed to (g).

(g) Tune C8 for maximum flatness of the signal.

(h) Final waveform should appear as in step (3) above.

25C. Control Slidewire Adjustment

The following adjustment should be made before placing the process on control. Subsequently, it should be repeated whenever a new controller chassis is substituted for the one in use.

(1) Set the controller dials thus:

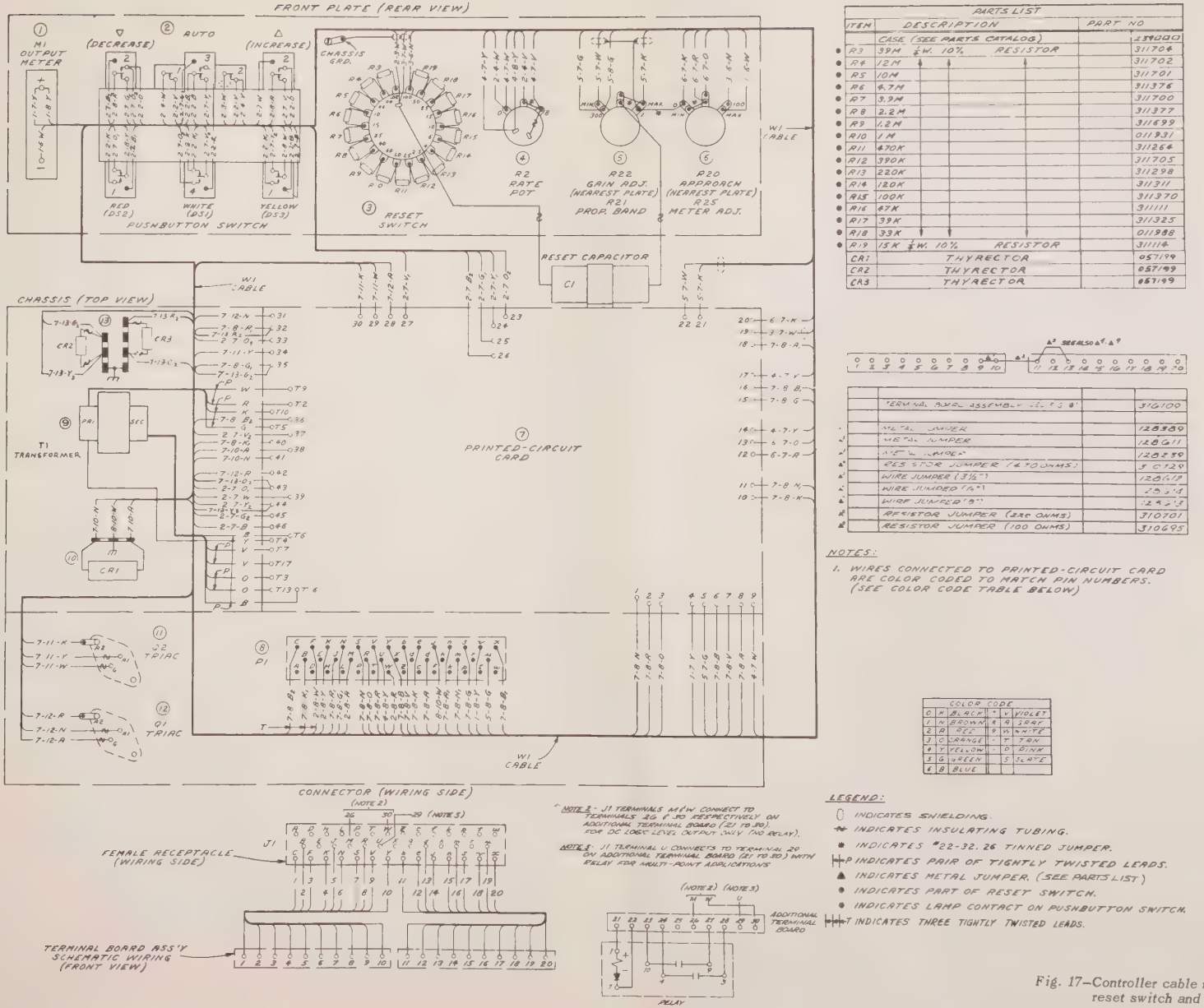
Proportional Band	20
(Proportional Gain	5)
Reset	10
Rate Time	0
Approach	OFF

(2) Depress the yellow manual pushbutton to bring the panel meter to approximately midscale.

(3) With the set point indicator and measuring pointer together, switch to AUTO. Adjust the amplifier gain to just keep the drive unit from hunting.

(4) Keeping the scale pointers together, adjust the position of the control slidewire to stop any drift of the meter reading.

(5) Gradually increase the setting of the RESET dial, making small control slidewire readjustments to hold the meter reading steady. The final adjustment should be made with the RESET dial at 100. Note that if the meter goes off scale at any time, it can be brought on scale by temporarily switching to manual operation, resetting the panel meter to midscale and then transferring back to AUTO.



PARTS LIST			
ITEM	DESCRIPTION		PART NO
	CASE (SEE PARTS CATALOG)		239000
R3	39M ½W. 10% RESISTOR		311704
R4	12M		311702
R5	10M		311701
R6	4.7M		311376
R7	3.9M		311700
R8	2.2M		311377
R9	1.2M		311699
R10	1M		011931
R11	470K		311264
R12	390K		311705
R13	220K		311298
R14	120K		311311
R15	100K		311370
R16	47K		311111
R17	33K		311325
R18	33K		011988
R19	15K ½W. 10% RESISTOR		311114
CR1	THYRECTOR		057199
CR2	THYRECTOR		057199
CR3	THYRECTOR		057199

	TERMINAL BOARD ASSEMBLY (SEE FIG 8)	316100
	METAL JUMPER	128389
	METAL JUMPER	128611
	WIRE JUMPER	128239
	RESISTOR JUMPER (470 OHMS)	SEE FIG 8
	WIRE JUMPER (3½")	126619
	WIRE JUMPER (7½")	SEE FIG 8
	WIRE JUMPER (9")	124313
	RESISTOR JUMPER (220 OHMS)	310701
	RESISTOR JUMPER (100 OHMS)	310695

NOTES:

1. WIRES CONNECTED TO PRINTED-CIRCUIT CARD ARE COLOR CODED TO MATCH PIN NUMBERS. (SEE COLOR CODE TABLE BELOW)

COLOR CODE					
0	K	BLACK	7	V	VIOLET
1	N	BROWN	8	G	GRAY
2	R	RED	9	W	WHITE
3	O	ORANGE	-	T	TAN
4	Y	YELLOW	-	D	PINK
5	G	GREEN	-	S	SLATE
6	B	BLUE			

NOTE 2 - J1 TERMINALS M & W CONNECT TO TERMINALS 26 & 30 RESPECTIVELY ON ADDITIONAL TERMINAL BOARD (21 TO 30). FOR DC LOGIC LEVEL OUTPUT ONLY (NO RELAY).

NOTE 3 - J1 TERMINAL U CONNECTS TO TERMINAL 20 ON ADDITIONAL TERMINAL BOARD (21 TO 30) WITH RELAY FOR MULTI-POINT APPLICATIONS.

LEGEND:

- INDICATES SHIELDING.
- INDICATES INSULATING TUBING.
- INDICATES #22-32. 26 TINNED JUMPER.
- P INDICATES PAIR OF TIGHTLY TWISTED LEADS.
- INDICATES METAL JUMPER. (SEE PARTS LIST)
- INDICATES PART OF RESET SWITCH.
- INDICATES LAMP CONTACT ON PUSHBUTTON SWITCH.
- T INDICATES THREE TIGHTLY TWISTED LEADS.

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Fig. 17—Controller cable routing and parts list for reset switch and terminal board jumpers.

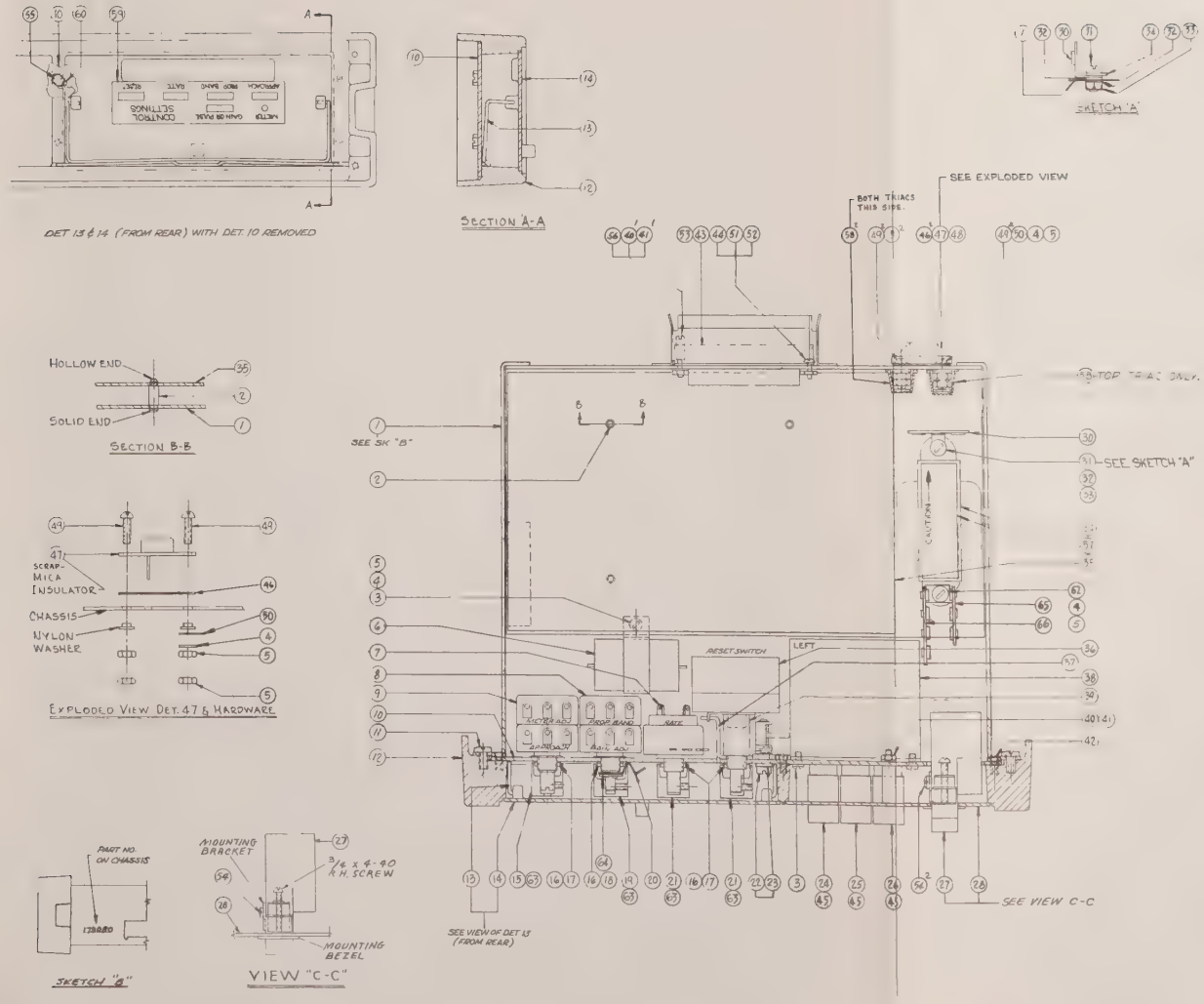


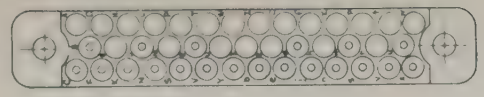
Fig. 18–Controller parts list. See also Fig. 17.

P.A.T. CONTROLLER PARTS LIST

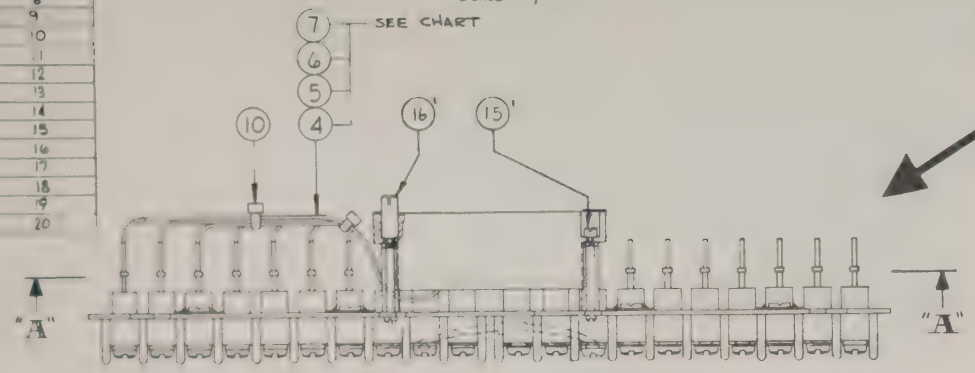
DET	QTY	DESCRIPTION	L&N PART NO.
1	1	Chassis Assembly	139192
2	4	Spacer	301179
3	5	5/16 6-32 Bind. Hd. B. Cr. P.	---
4	4	#1106 SPLW	----
5	10	6-32 Br. Nut Cr. P.	----
6	1	Capacitor (40 μF, 50 V)	023672
7	1	Potentiometer (2.0 Meg.)	013141
8	1	Potentiometer (Dual 10 K and 30 K)	013477
9	1	Potentiometer (Dual 15 K and 15 K)	013474
10	1	Plate	269644
11	4	5/16 8-32 Type "F" Thd. Cutting Scr. (Pan Hd.)	----
12	1	Support Frame (Medium Gray)	127679
13	1	Spring	028392
14	1	Casting (Door)	239710
15	1	Knob (17/64 Shaft, Index and Hole)	002323
16	4	Lock Washer 3/8	001802
17	3	Nut (3/8-32 Thread)	003325
18	1	Nut (3/8-32 Thread) 29/64 O.D.	003436
19	1	Knob (3/16 Shaft, with Index)	002329
20	1	Index	048112
21	2	Knob (1/4 Shaft, with Index)	002322
22	1	Fastener (Adjustable Pawl)	089039
23	1	Round Nut (5/16-32)	003441
24	1	Pushbutton (Snap-On Yellow)	042184
25	1	Pushbutton (Snap-On White)	042185
26	1	Pushbutton (Snap-On Red)	042186
27	1	DC Meter (1 Milliampere)	021162
28	1	Plate	269536
30	1	Tie Point (3 Points)	016521
31	1	5/16 8-32 R. Hd. B. Cr. P.	----
32	2	#1108 SPLW	----
33	1	8-32 Br. Nut Cr. P.	----
*34	1	Transformer	019450
35	1	Printed-Circuit Card	444472
36	1	Switch (1-Pole, 18 Point with Resistors)	031521
37	1	Bracket	073829
38	**	Switch, 3-Station Lighted Pushbutton	032437
39	1	Bushing	006650
40	3	4-40 Br. Nut Cr. P.	----
41	3	#4 KLLW	----
42	5	1/4 6-32 Type "F" Thr. Cutting Scr. (Slotted Hex. Hd.)	----
43	**	Receptacle, Male (41 Contacts)	040580Δ
44	1	1/2 x 3-48 R. Hd. Br. Cr. P.	----
45	1	Lamp	026074
46	2	Insulator	034689
47	1	Thyristor (Triac—Incl. Insulator and Washers)	050202
48	2	Cover	267140
49	1	1/2 6-32 R. Hd. Br. Cr. P.	----
50	2	Terminal Lug	Std. 8[ES]
51	1	3-48 Br. Nut Cr. P.	----
52	1	#3 Light KLLW	----
53	1	Cable Assembly (Includes Details 38 and 43)	237829
54	2	3/16 x 2-56 Binding Hd. Br. Scr.	----
55	1	5/16 x 6-32 Type "F" Thr. Cutting Scr. (Slotted Hex. Hd.)	----
56	1	Stud	061743
57	1	Label	287370
58	3	Protector	095104
59	1	Label	287371
60	1	Solder Lug	16-4-5-2
61	1	#6 Br. Washer	----
62	1	3/8 x 6-32 R. Hd. Br. N. P.	----
63	4	3/16 x 4-40 Setscrew, Hex. Socket, Flat Point	----
64	1	Retaining Ring	----
65	1	Tie Point (3 Points)	027194
66	1	Tie Point (4 Points)	016570
			16-7-0-1

*Recommended for spare parts stock.
**Part of Detail 53.
Δ For terminal contacts see following figure notation.

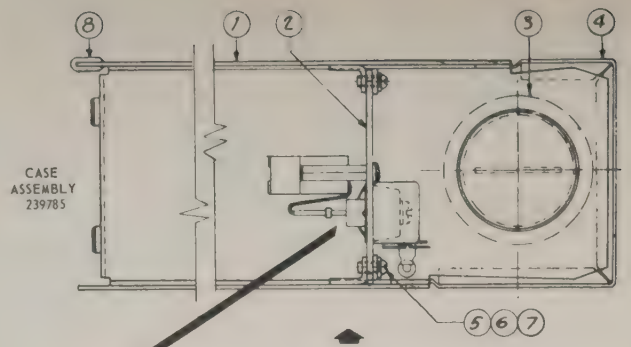
DET NO	RECEPTACLE POSITION	TERMINAL TO POSITION
4	C	1
4	B	2
4	F	3
5	K	4
5	J	5
6	N	6
6	S	7
7	R	8
7	V	9
7	Y	10
7	b	11
7	e	12
7	d	13
6	L	14
6	h	15
5	m	16
5	s	17
4	v	18
4	u	19
4	x	20



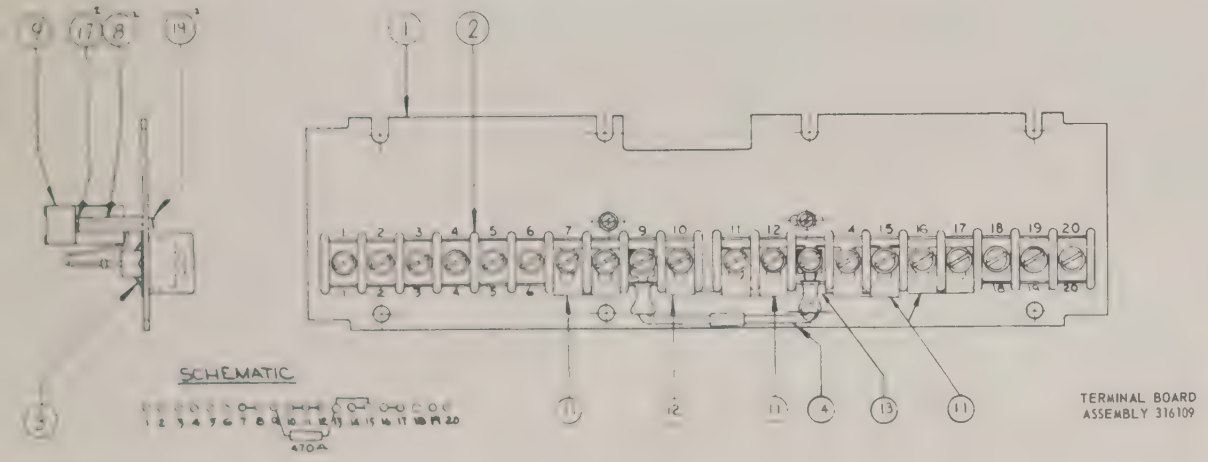
VIEW "A-A"
SCALE- 2/1



10674



DET	QTY	DESCRIPTION	L&N PART NO.
1	1	Case Assembly (Medium Gray)	239814
2	1	Terminal Board Assembly	316109
3	2	Plug Button (1-3/8 Dia.)	042203
4	1	Cover (Medium Gray)	267374
5	8	1/4 x #6-32 R.H.B. Sc. Cr. P.	- - -
6	8	#6 K.L.L.W.	- - -
7	8	#6 Plain Washer	- - -
8	1	Gasket	096418



DET	QTY	DESCRIPTION	L&N PART NO.
1	1	Mounting Plate	269576
2	2	Terminal Board (10 Pt.)	316108
3	4	Fastener	003435
4	6	Lead (5-1/2) Green	237604
5	4	Lead (4-1/2) Yellow	237603
6	4	Lead (3-1/2) Orange	237602
7	6	Lead (2-1/2) Red Stripe	237601
8	2	Stud	061641
9	1	Connector (Female)	040581
10	4	Fastener (Cable Wrap)	089037
11	4	Jumper	128389
12	1	Jumper	128611
13	1	Jumper	128239
14	1	Jumper (With 470Ω Res.)	310729
15	1	1/4 x #4-40 Fil. Hd. B.	- - -
16	1	Stud	061743
17	2	#4 K.L.L.W.	- - -
19	2	1/4 x 4-40 Bind. Hd. B. Cr. P.	- - -

DE5953

SERIES 80 TERMINALS

Female contacts 029737 in case connector 040581 and male contacts 029736 in chassis connector 040580 are inserted without a special tool, but they must be extracted with AMP Co. Tool #305183 (L&N Part No. 064201).

The leads from the case connector are connected to the case terminal board by pushing their contacts into the terminal board female sockets, or disconnected by pulling from the sockets. Long-nose pliers are required, or use AMP Co. Tool #380306-2 (L&N Part No. 064212).

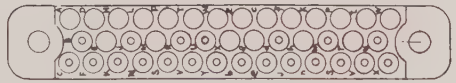
Female contacts 029737 are part of the leads used in assembling the case terminal board assembly. They are crimped on with AMP Co. Tool #90066 (L&N Part No. 064197). The other end of these leads has terminal 016870 crimped on with AMP Co. Tool #48698 (L&N Part No. 064213).

Male contacts 029736 are part of the chassis cable. They are crimped on with AMP Tool Co. #90066 (L&N Part No. 064197).

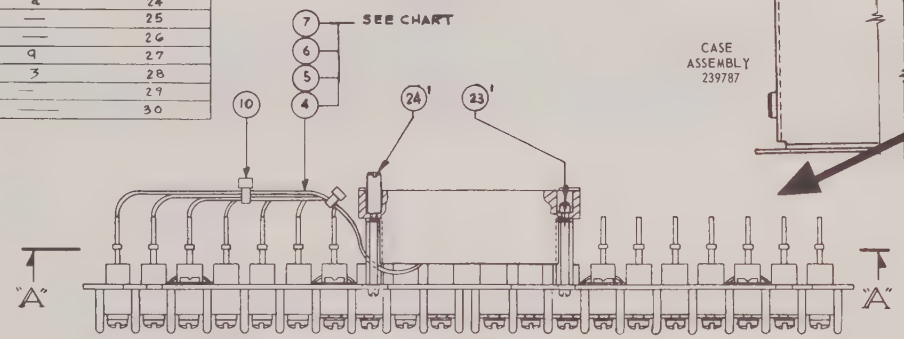
Fig. 18–(Continued).

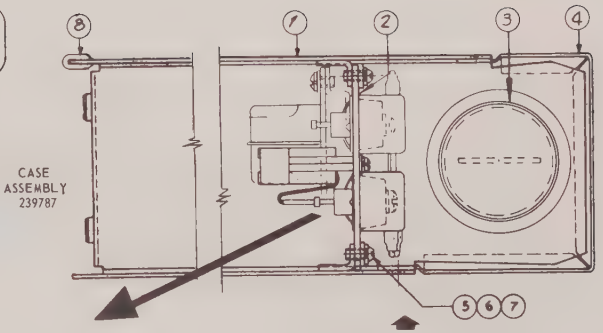
DET. NO.	RECEPTACLE POSITION	TO TERMINAL POSITION
4	C	1
4	E	2
4	F	3
5	K	4
5	J	5
6	N	6
6	S	7
7	R	8
7	V	9
7	Y	10
7	b	11
7	e	12
7	d	13
6	J	14
6	h	15
5	m	16
5	s	17
4	v	18
4	u	19
4	x	20
7	U	29

RELAY P.C.	TO TERMINAL POSITION
1	21
7	22
10	23
4	24
—	25
—	26
9	27
3	28
—	29
—	30



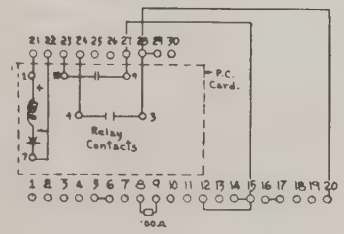
VIEW "A-A"



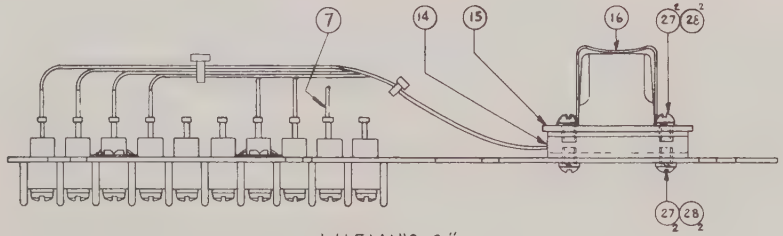


DET	QTY	DESCRIPTION	L&N PART NO.
1	1	Case Assembly (Medium Gray)	239814
2	1	Terminal Board Assembly	016899
3	2	Plug Button (1-3/8 Dia.)	042203
4	1	Cover (Medium Gray)	267374
5	8	1/4 x #6-32 R.H.B. Sc. Cr. P.	- - -
6	8	#6 K.L.L.W.	- - -
7	8	#6 Plain Washer	- - -
8	1	Gasket	096418

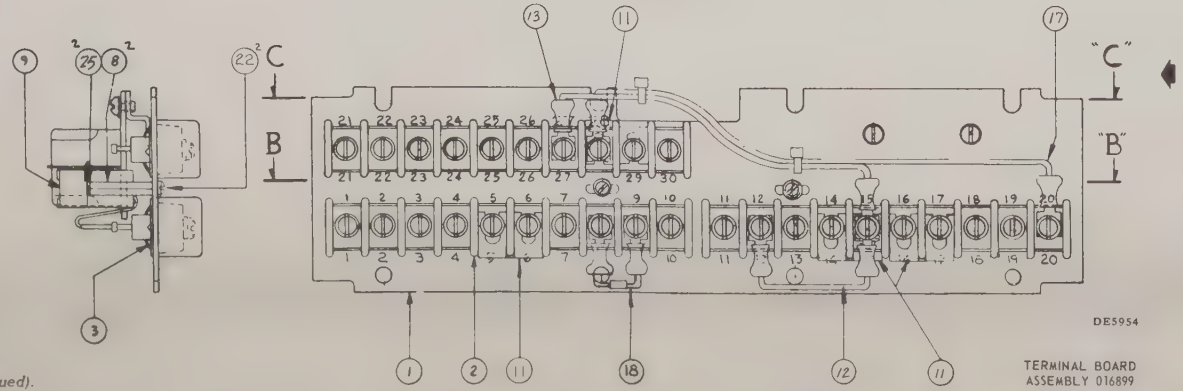
SCHEMATIC



VIEW "B-B"



VIEW "C-C"

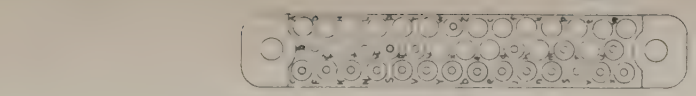


TERMINAL BOARD ASSEMBLY 016899

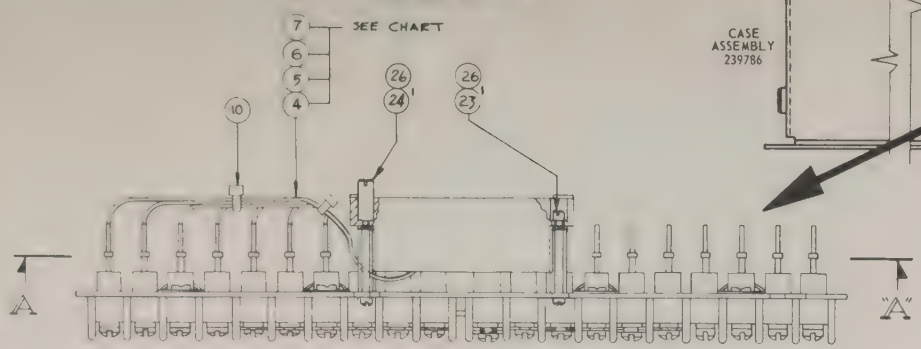
DET	QTY	DESCRIPTION	L&N PART NO.
1	1	Mounting Plate	269697
2	3	Terminal Board (10 Pt.)	316108
3	6	Fastener	003435
4	6	Lead (5-1/2) Green	237604
5	4	Lead (4-1/2) Yellow	237603
6	4	Lead (3-1/2) Orange	237602
7	7	Lead (2-1/2) Red	237601
8	2	Stud	061641
9	1	Connector (Female)	040581
10	8	Fastener (Cable Wrap)	089037
11	4	Jumper	128389
12	1	Jumper	128612
13	1	Jumper	128614
14	1	Bracket (Z Shaped)	273499
15	1	Relay P.C. Board	444475
16	1	Relay	036295
17	1	Jumper	128613
18	1	Resistor (With Terminal Lug)	310695
22	2	1/4 x #4-40 Bind. Hd. B.,Cr. P.	- - -
23	1	1/4 x #4-40 Fil. Hd. B.	- - -
24	1	Stud	061743
25	2	#4 K.L.L.W.	- - -
27	4	1/4 x #6-32	- - -
28	4	#6 K.L.L.W.	- - -

Fig. 18–(Continued).

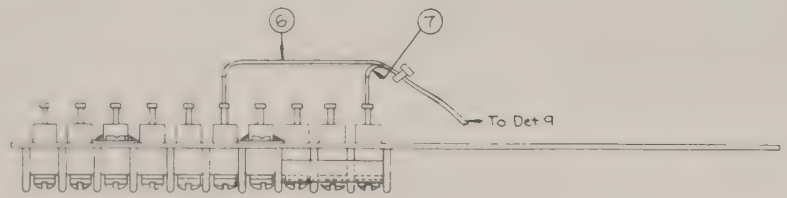
Det No	Receptacle Position	To	Terminal Position
4	C		1
4	B		2
4	F		3
3	K		4
5	J		5
6	N		6
6	S		7
7	R		8
7	V		9
7	Y		10
7	b		11
7	e		12
7	d		13
6	J		14
6	n		15
3	m		16
3	s		17
4	x		18
4	u		19
4	X		20
6	M		26
7	W		30



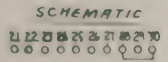
VIEW "A-A"

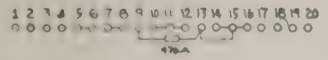


VIEW "B-B"

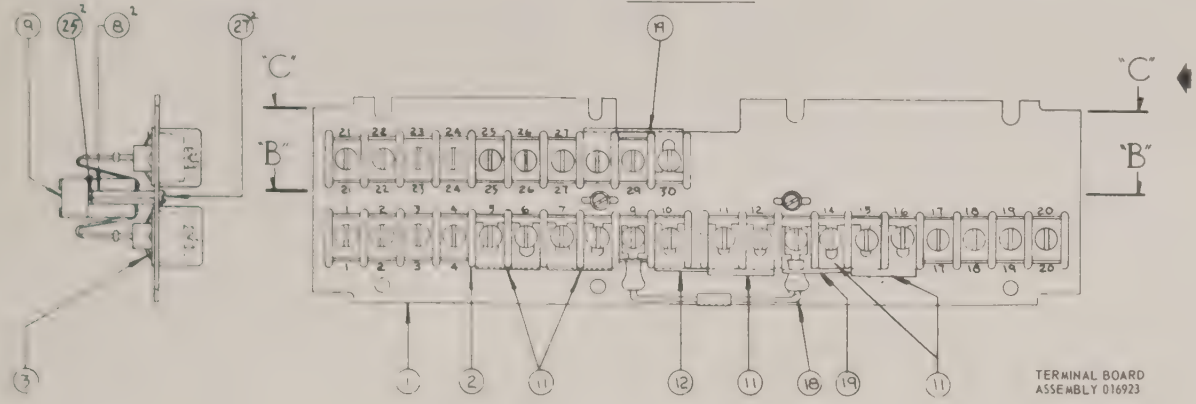


SCHEMATIC

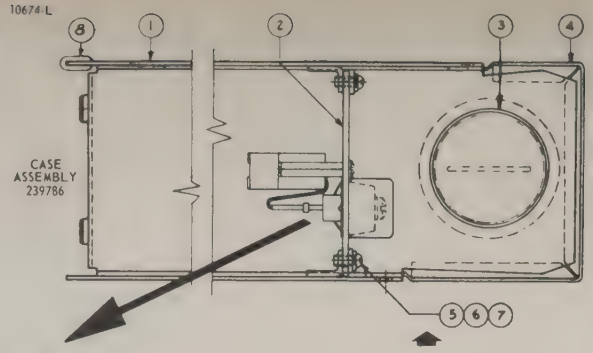




VIEW "C-C"



DE6157



DET	QTY	DESCRIPTION	L&N PART NO.
1	1	Case Assembly (Medium Gray)	239814
2	1	Terminal Board Assembly	016923
3	2	Plug Button (1-3/8 Dia.)	042203
4	1	Cover (Medium Gray)	267374
5	8	1/4 x #6-32 R.H.B. Sc. Cr. P.	----
6	8	#6 K. L. L. W.	----
7	8	#6 Plain Washer	----
8	1	Gasket	096418

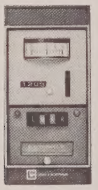
DET	QTY	DESCRIPTION	L&N PART NO.
1	1	Mounting Plate	269697
2	3	Terminal Board (10 Pt.)	316108
3	6	Fastener	003435
4	6	Lead (5-1/2) Green	237604
5	4	Lead (4-1/2) Yellow	237603
6	5	Lead (3-1/2) Orange	237602
7	7	Lead (2-1/2) Red	237601
8	2	Stud	061641
9	1	Connector (Female)	040581
10	5	Fastener (Cable Wrap)	089037
11	5	Jumper	128389
12	1	Jumper	128611
18	1	Jumper (With 470Ω Res.)	310729
19	2	Jumper	128239
23	1	1/4 x #4-40 Fil. Hd. B.	----
24	1	Stud	061743
25	2	#4 K. L. L. W.	----
27	2	1/4 x #4-40 Bind. Hd. B. Cr. P.	----

Fig. 18–(Concluded).

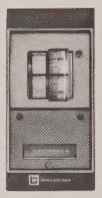
NOTES

Electromax III:

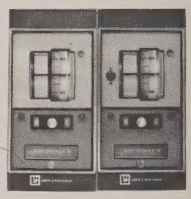
Key to One-Stop Shopping for Controlling – Alarming – Recording/Controlling – Programmed Control



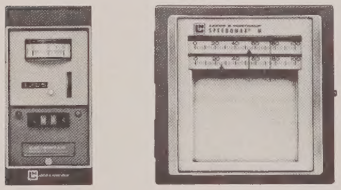
Electromax III Universal Controller
Model illustrated has Digital Setter, Deviation Meter and Auto/Manual Station.



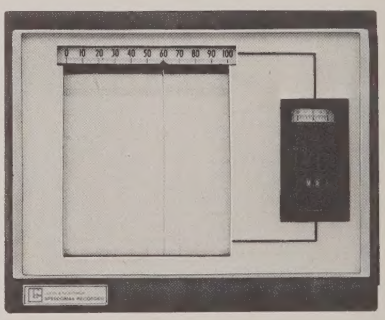
Electromax III for On-Off Control or Alarming
Model illustrated has Analog Setter and Deviation Meter.



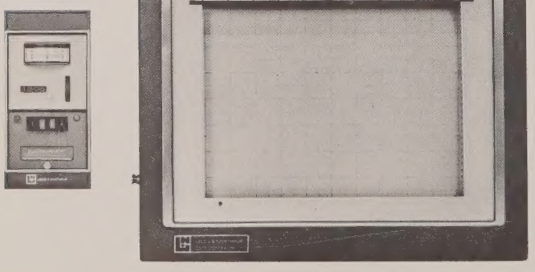
Electromax III Cascade Control
6430 V.A.T. Controller output provides set-point signal for secondary controller. Latter (at right) has Remote/Local Switch to permit tuning or local control with built-in setter.



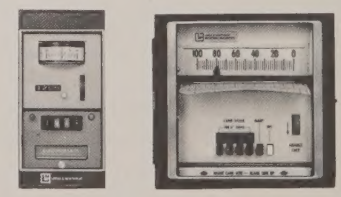
Electromax III and Speedomax M Mark II Recorder
Optional high-level signal output from Electromax III, proportional to input, permits the use of low-cost miniature recorder with 4" chart and one, two or three pens for independent channels.



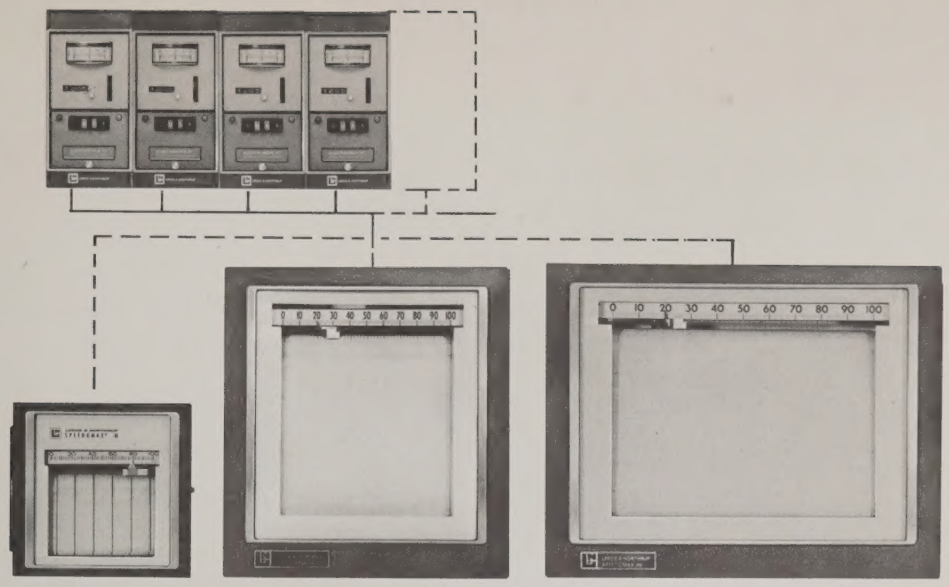
Electromax/Speedomax "Package"
Combines reliable round-chart or strip-chart Speedomax H recording with direct-acting Electromax III control in one compact case. Recorder can actuate signals or alarms independent of controller.



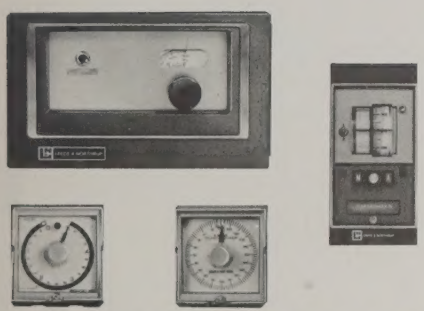
Electromax III and Speedomax W Recorder
For detailed recording on a 10" strip-chart, controller and recorder can share the input signal (independent operation), or recorder can be provided to operate on optional high-level signal from Electromax III.



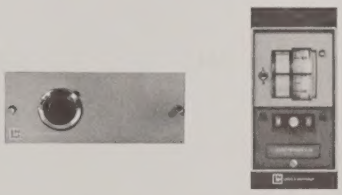
Electromax III and Infotrak® Card-Chart Recorder
For batch-process operations, Infotrak provides graphic records on 5" x 8" cards, easily fileable, rapidly retrievable. High-level circuit responds to optional high-level signal from Electromax III.



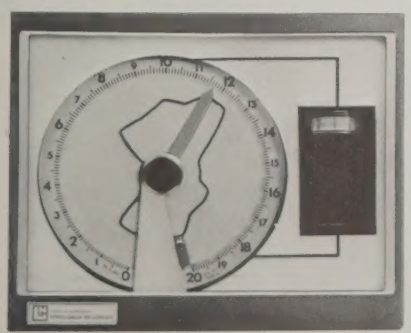
Electromax III and Multi-Point Recorders
Where multiple Electromax controllers are employed and detailed records of controlled variables are also required, multi-point curve-printing Speedomax recorders are available: Speedomax M (4" chart) for 4 or 6 points, Speedomax H (6½" chart) for 2 to 12 points, Speedomax W (10" chart) for 2 to 24 points. Switching optional high-level signal from Electromax III can assure uninterrupted control.



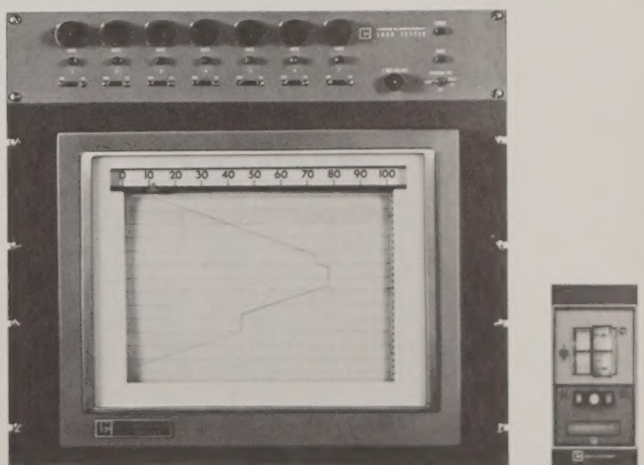
Electromax III and 10173 Program Set-Point Controller
The 10173 Controller offers single-soak linear programming; combined with a Rate Controller and Soak Timer to permit adjustable heating and cooling rates and soak periods, the 10173 provides a set-point signal to Electromax III.



Electromax III and 10188 Motor-Operated Set-Point Unit
The 10188 Unit offers simple linear programming of Electromax III by providing a set-point signal changed at a predetermined rate.



Electromax/Trendtrak "Package"
Combines Trendtrak Curve-Following Programmer with Electromax III in one compact case for linear or non-linear program controlling. Cycle drawn on Trendtrak disc results in programmed set-point for Electromax.



Electromax III and Speedomax W Motor-Operated Set-Point Program Controller
The Speedomax W MOSP Program Controller provides fully automatic linear programming with as many as seven traverses and soaks, generating the appropriate set-point signal for Electromax III and recording the controlled variable.

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